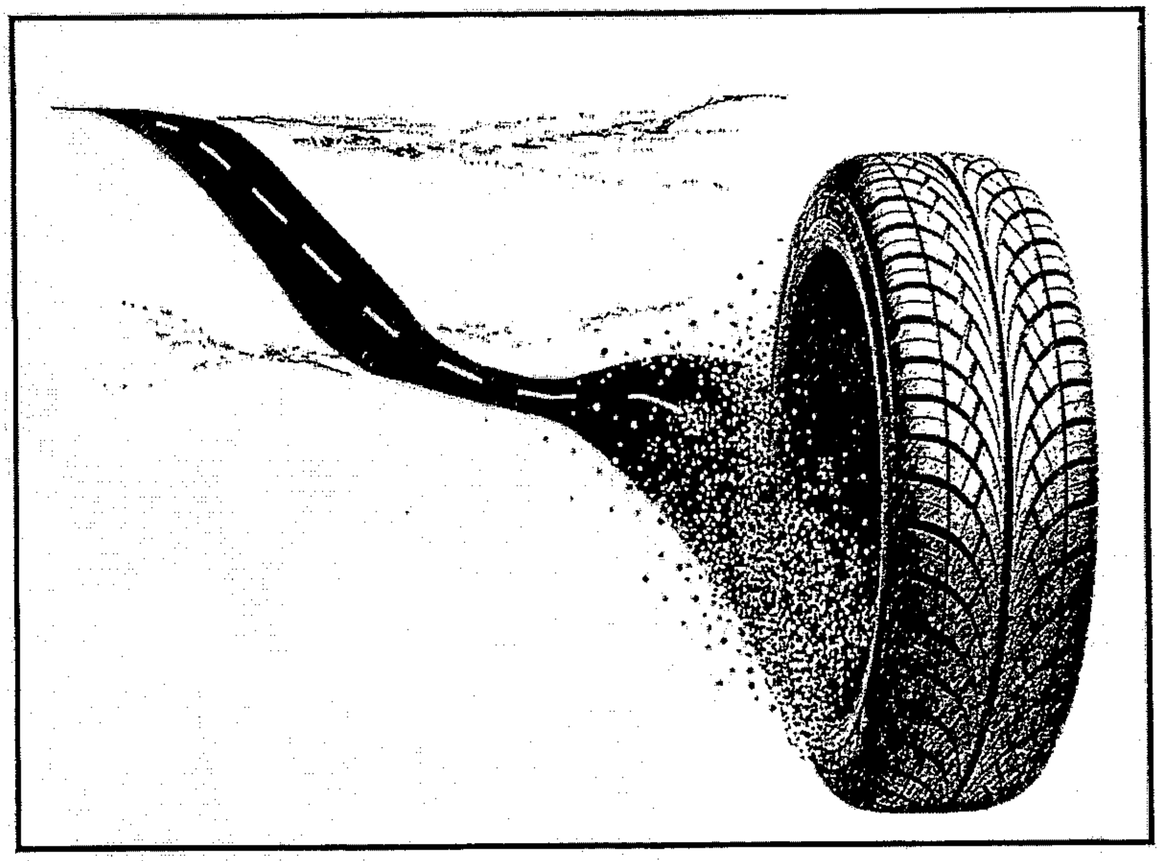
PERFORMANCE OF RUBBERIZED ASPHALT PAVEMENTS IN ILLINOIS



PHYSICAL RESEARCH REPORT NO. 136
DECEMBER 2000

Illinois Department of Transportation
Bureau of Materials and Physical Research
126 East Ash Street / Springfield, Illinois / 62704-4766

PERFORMANCE OF RUBBERIZED ASPHALT PAVEMENTS IN ILLINOIS

By:

Tessa H. Volle
Materials Investigations Engineer

Illinois Department of Transportation
Bureau of Materials and Physical Research
Springfield, Illinois 62707

December 2000

Technical Report Documentation Page

1. Report No. FHWA/IL/PRR-136	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle PERFORMANCE OF RUBBERIZED ASPHALT PAVEMENTS IN ILLINOIS		5. Report Date December 2000 6. Performing Organization Code
7. Author(s) Tessa H. Volle		8. Performing Organization Report No. Physical Research No. 136
9. Performing Organization Name and Address Illinois Department of Transportation Bureau of Materials and Physical Research 126 East Ash Street Springfield, Illinois 62704-4766		10. Work Unit (TRAIS) 11. Contract or Grant No. IHR-R07
12. Sponsoring Agency Name and Address Illinois Department of Transportation Bureau of Materials and Physical Research 126 East Ash Street Springfield, Illinois 62704-4766		13. Type of Report and Period Covered Final Report *October 1991 – March 1999* 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

In 1991, the Illinois Department of Transportation began a program to incorporate scrap tire rubber as a modifier in selected hot-mix asphalt (HMA) paving projects. This effort was a response to the requirements of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. In 1995, when the department ended its efforts in crumb rubber modifier (CRM) usage, eleven crumb rubber projects had been constructed. By that time, Section 1038 of ISTEA was modified by subsequent federal legislation and the mandate was repealed.

Two methods were used in Illinois to combine CRM with HMA: the wet process and the dry process. Two terms have been used in Illinois to define the various quantities of CRM added to HMA: variable rate and fixed rate. Variable rate defines a small quantity of CRM added to the HMA: no more than five pounds of CRM per ton of HMA. Fixed rate defines a larger quantity: no less than twenty pounds of CRM per ton of HMA.

This report includes a cost summary in which the final bid prices of HMA containing CRM for each project are compared to costs of conventional HMA in Illinois. However, the main purpose of this report is to summarize the performance monitoring of the eleven crumb rubber modified HMA projects in Illinois through March 31, 1999. Performance monitoring of most of the rubberized asphalt pavements includes the following: visual distress surveys and surface property characteristics.

17. Key Words crumb rubber modifier (CRM), rubberized asphalt, wet process, dry process, performance, distress surveys, friction, International Roughness Index (IRI), rut values	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 133	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

ACKNOWLEDGMENTS

The author gratefully acknowledges the contributions of the following people: Jim Trepanier for furnishing background information; James White of Bureau of Design and Environment, Paul Wilson of District 2, Herb Jung of District 3, Ray Seneca of District 4, and Cecil Downing and Jerry Parsons of District 6 for cost information; Bill Rhoads, Tim Kennedy, Paul Guthrie, Chris Volkman, and Laura Heckel for their assistance in collecting visual survey data; the Operations Unit of the Pavement Technology Section for collecting the friction, International Roughness Index (IRI), and rutting data with the Video Inspection Vehicle (VIV); David Bernardin for processing the IRI and rutting data; and Matthew Mueller, Amy Schutzbach, Laura Shanley, Jeffrey South, David Taylor, and Jim Trepanier for manuscript review.

EXECUTIVE SUMMARY

In 1991, the Illinois Department of Transportation (IDOT) began a program to incorporate scrap tire rubber as a modifier in selected hot-mix asphalt (HMA) paving projects. This effort was a response to the requirements of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. Section 1038 of ISTEA required each state to study the performance, recycling, and environmental aspects of crumb rubber modifier (CRM) in asphalt pavement. The legislation mandated that states use minimum quantities of CRM in HMA beginning in 1994 and continuously increase quantities through 1997. In 1995, when IDOT ended its efforts in CRM usage, eleven crumb rubber projects had been constructed. By that time, Section 1038 of ISTEA was modified by subsequent federal legislation and the mandate was repealed.

Two methods were used in Illinois to combine CRM and HMA: the wet process and the dry process. The wet process defines a method in which CRM is added to the liquid asphalt cement (AC) prior to mixing AC with the aggregate. The dry process defines a method in which CRM is added to the hot aggregate prior to the addition of the AC. Only one of the eleven projects in Illinois was constructed with CRM and HMA blended by the wet process.

Two terms have been used in Illinois to define the various quantities of CRM added to HMA: variable rate and fixed rate. Variable rate defines a small quantity of CRM added to the HMA: no more than five pounds of CRM per ton of HMA. Fixed rate defines a larger quantity: no less than twenty pounds of CRM per ton of HMA. Between 1991 and 1995, six projects with variable rate sections and seven projects with fixed rate sections were constructed in Illinois. Two projects were constructed with both variable rate and fixed rate sections. Most of the rubberized asphalt projects contain control sections with the department's conventional HMA in addition to the variable rate and/or fixed rate sections.

This report includes a cost summary in which the final bid prices of HMA containing CRM for each project are compared to the final bid prices of conventional HMA used in the projects. However, the main purpose of this report is to summarize the performance monitoring of the eleven crumb rubber modified HMA projects in Illinois through March 31, 1999. Performance monitoring of most of the rubberized asphalt pavements included visual distress surveys and surface property characteristics.

Conclusions based on the cost and performance data are as follows:

1. On average, the HMA mix containing CRM for all the rubberized asphalt projects was 30% higher in cost than conventional HMA.
2. The one project in which the CRM and HMA were mixed by the wet process was 101% higher in cost than conventional HMA.
3. The cost for using CRM ranged from \$0.28 to \$5.30 per pound of CRM utilized.
4. On average, the CRM mix used in projects where the CRM and HMA were mixed by the dry process was 17% higher in cost than conventional HMA.
5. Based on the visual survey data, the sections rank in the following order from best overall performance to worst: fixed rate (wet method), control (no CRM), variable rate (dry method), and fixed rate (dry method).
6. According to the limited amount of pre-construction distress survey data available, the wet process appeared to be more effective than the dry process in producing a modified HMA mixture resilient to reflective cracking.
7. According to the Department's rating guidelines for friction numbers, all the treaded and smooth tire friction numbers collected in the rubberized asphalt projects were within an acceptable range of friction numbers.
8. The IRI values for the CRM and control sections were within a range of 63 to 184 inches per mile. No substantial difference in the IRI values was evident between the CRM and control sections.
9. The rut values for the CRM and control sections were in the range of 0.02 – 0.14 inches, which is well below the department's acceptable limit. Again, no substantial difference in the rut values was noted between the CRM and control sections.

There are key economic and technical barriers that need to be overcome before CRM can be successfully used in Illinois:

1. Even with the improved performance of the wet method, the 101% increase in cost dictates that the pavement needs to last at least two times longer than a conventional HMA pavement.

2. The dry process results in a slight reduction in performance. Therefore, it is not considered economically viable.

3. Rubberized asphalt is not a consistent product that can be performance graded in accordance with standardized quality control tests.

4. In order for CRM to be more economically viable, CRM needs to be mass-produced at a local level. Furthermore, the investment that local industry must make in purchasing the equipment to produce rubberized asphalt will not give them financial return unless the demand for rubberized asphalt increases substantially. A significant improvement in performance of a rubberized asphalt pavement in contrast to conventional HMA is necessary before there will be an increased demand for the material.

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

In 1991, the Illinois Department of Transportation (IDOT) began a program to incorporate scrap tire rubber as a modifier in selected hot-mix asphalt (HMA) paving projects. This effort was a response to the requirements of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. Section 1038 of this legislation required each state to study the performance, recycling, and environmental aspects of crumb rubber modifier (CRM) in asphalt pavement [1]. This legislation mandated that the percentage of CRM in asphalt paving was to begin at 5% in 1994 and increase by 5% each year until 1997 when the percentage would be 20%. The percentage was to remain at 20% each year thereafter. Specifically, Section 1038(d) mandated that the percentages of total tons of HMA funded with federal funds must contain an average of 20 pounds of CRM per ton of mixture. For Illinois, the minimum CRM usage was 3 million pounds beginning in 1994. The quantity was to be increased 3 million pounds every year to a maximum of 12 million pounds in 1997 [2]. Noncompliance by any state with this legislation would result in severe Federal funding reduction.

Between 1993 and 1995, Section 1038 of ISTEA had been modified by subsequent federal legislation. By 1995, the mandate and all associated penalties were repealed. When the department ended its efforts in CRM usage in 1995, eleven crumb rubber projects had been constructed.

Two methods were used in Illinois to combine CRM with HMA: the wet process and the dry process. The wet process defines a method in which CRM is added to the liquid asphalt cement (AC) prior to mixing AC with the aggregate. The dry process defines a method in which CRM is added to the hot aggregate prior to the addition of the AC [3]. Only one of the eleven projects in Illinois was constructed with CRM and HMA blended by the wet process.

Two terms have been used in Illinois to define the various quantities of CRM added to HMA: variable rate and fixed rate. Variable rate defines a small quantity of CRM added to the HMA: no more than five pounds of CRM per ton of HMA. Fixed rate defines a larger quantity: no less than twenty pounds of CRM per ton of HMA [4]. Between 1991 and 1995, six projects with variable rate sections and seven projects with fixed rate sections were constructed in Illinois. Two projects were constructed with both variable rate and fixed rate sections.

This report includes a cost summary in which the final bid prices of HMA containing CRM for each project are compared to the final bid prices of conventional HMA used in the projects. However, the main purpose of this report is to summarize the performance monitoring of the eleven crumb rubber modified HMA projects in Illinois. Most of the projects contain control sections with the department's conventional HMA in addition to the variable rate and/or fixed rate sections. Therefore, the sections containing CRM and the control sections will be compared.

Performance monitoring of most of the rubberized asphalt pavements included visual distress surveys and surface property characteristics. This report summarizes the results of the data collection efforts through March 31, 1999.

Table 1 contains project locations and a general summary of the rubberized asphalt pavements constructed between 1991 and 1995 in Illinois. Table 2 contains the pavement design, quantities of crumb rubber in each project, and other related information. Total miles of surface paved in each project, including a breakdown of the miles of control, fixed rate, and variable rate sections in each project, are included in Table 3. Project maps are located in Appendix A. Typical special provisions for the rubberized asphalt projects are located in Appendix B. Appendix C contains job mix formulas for all the rubberized asphalt projects.

COST COMPARISONS

For all of the rubberized asphalt projects constructed in Illinois, costs for HMA containing CRM were higher than the costs for conventional HMA (no CRM). Table 4 contains cost information for all rubberized asphalt projects constructed in Illinois. Costs are presented as dollars per ton of material. The cost per ton of HMA includes material, placement, and compaction.

With the exception of Project C and H, the costs listed in Table 4 for the conventional HMA mixes are final bid prices ($/ton) of the conventional mix used in the project. Projects C and H were not constructed with any conventional HMA under the same contract. Therefore, a District average for an equivalent conventional HMA for the year of construction was used for comparison.

The average cost for HMA containing CRM was $41.96 per ton. Also included in Table 4 is the percent increase in cost of the HMA containing CRM in comparison to the conventional HMA used in the projects. The average cost increase of HMA containing CRM in all the projects (as compared to the conventional HMA) was 30%. In all projects, the HMA containing CRM was higher in cost than the conventional HMA. In fact, the cost for HMA containing CRM was at least 20% higher in cost in eight projects, over 30% higher in three projects, and over 100% higher in one project.

For the rubberized asphalt projects that contained variable rate (dry process) sections (Projects E, F, G, I, J, and K), the average cost for the HMA with small quantities of CRM was $36.28 per ton. The average cost increase for those projects was 17%. For the rubberized asphalt projects that contained fixed rate (dry process) sections (Projects A, C, D, H, J, and K), the average cost for HMA with large quantities of CRM was $40.71 per ton. The average cost increase for those projects was 29%.

Project B was constructed with CRM and HMA blended by the wet process. The extremely high cost of $80.00 per ton for the material used in Project B can be attributed to the specialized equipment necessary for the wet process. The cost increase for Project B was 101%. The dry process, which was used in all the other projects, did not require specialized equipment. The average cost for all the projects in which the dry process was used (all projects but Project B) was \$38.50; the average increase in cost for those projects was 23%.

Also given in Table 4 is a value labeled "Cost Rate". This value indicates the cost difference between the CRM modified HMA versus the conventional HMA with respect to the rate of CRM (pounds) added per ton of HMA. The rate of CRM added to the HMA for each project is included in Table 2. The cost rate value was calculated as follows:

$$\text{Cost Rate} = \frac{\text{Cost of HMA with CRM (\$/ton)} - \text{Cost of Conventional HMA (\$/ton)}}{\text{Rate of CRM Added to HMA (lb/ton)}}$$

For the rubberized asphalt projects that contained variable rate (dry process) sections (Projects E, F, G, I, J, and K), the average cost rate was \$2.23 per rate of CRM added to the HMA (lb/ton). For the rubberized asphalt projects that contained fixed rate (dry process) sections (Projects A, C, D, H, J, and K), the average cost rate was \$0.48 per rate of CRM added to the HMA (lb/ton). The higher cost rate of the variable rate projects indicates that even with adding small quantities of CRM to HMA (no more than five pounds of CRM per ton of HMA), the CRM caused the mix to be more expensive. The one project in which the wet process was used (Project B) had a cost rate of \$1.11 per rate of CRM added to the HMA (lb/ton). The CRM was added at a fixed rate in Project B. The average cost rate of the dry process projects (all projects but Project B) was \$0.50 for each pound utilized.

The overall cost increase of HMA containing CRM as compared to conventional HMA could be attributed to the following costs to the contractor: cost of CRM processed from scrap tires, manual labor to feed CRM into the system, and the contractor's unfamiliarity in using CRM. As mentioned previously, the high increase in cost when the wet process was used is attributed to the specialized equipment required.

TRAFFIC

The number of passenger vehicles (PV), single unit (SU) trucks and multiple unit (MU) trucks were determined on each route through calculations from the average daily traffic data. From the PV's, SU's, and MU's for each year, the Equivalent Single Axle Loads (ESALs) per year were calculated for each route. The resulting ESAL value represents the number of truck axles if all were loaded to 18,000 pounds. The cumulative ESALs were determined based on the age of the section to date. Table 5 contains the traffic data for each rubberized asphalt project in Illinois.

Table 5 mainly serves as background information for the reader. In this report, the focus of the author is to compare performance data between the CRM sections and control sections contained in one project rather than comparing one project to another. The reason for this focus is that the existing pavement age and condition, overlay age and thickness, traffic loading, environmental conditions, and other factors are likely to be similar for the CRM and control sections contained in a given project. However, most of those factors would most likely not be similar for the CRM and control sections from one project to another. Table 5 is presented mainly to help the reader understand possible reasons why one particular project seems to have exceptionally good or poor performance.

VISUAL DISTRESS SURVEYS

The rubberized asphalt projects were visually surveyed at various times between 1991 and 1998. Years of the distress surveys and miles surveyed in each project can be found in Table 6.

During each distress survey conducted on the rubberized asphalt pavements, distress locations, quantities, and severity levels were recorded. Summaries of the distresses, categorized by severity and age of pavement, are located in Tables 7 - 10. The "age of pavement" simply indicates the age at the time of the distress survey since the rubberized asphalt was placed. The quantities of each distress represent the length of the distress in miles (or number of cracks) per mile that was surveyed for that age of pavement [5]. In other words, the quantity of the distress is given as a percentage of the length surveyed. Definitions of each distress are taken from the IDOT Pavement Distress Manual. Copies of the relevant distress definitions from the IDOT Pavement Distress Manual are included in Appendix D.

Graphical representations of the data can be found in Appendix E, Figures E1 - E9. These bar graphs should facilitate better comparison of the performance between control, variable rate, and fixed rate sections. Tables 7 - 10 and Figures E1 - E9 summarize the appropriate sections of all the rubberized asphalt pavements together.

Based on the assumption that the existing pavement age and condition, overlay age and thickness, traffic loading, environmental conditions, and other factors have been similar for the control, variable rate, and/or fixed rate sections contained in a given project, sections within each individual project should be compared. Graphical representations of the distress quantities for each individual rubberized asphalt project can be found in Appendix F (Figures F1 - F66).

IL 76 (Project J) was not entirely surveyed and is not included in the distress survey summaries presented in Tables 7 - 10 and Appendix E and F. In this project, sections containing CRM were paved only in the shoulder, while the mainline was paved with conventional HMA. Therefore, traffic loading on the CRM sections was negligible compared to the traffic loading on the control sections in the mainline. Due to time constraints, Project J was not considered a critical pavement to include in the visual surveys.

As seen in Table 6, no project was surveyed every year. In fact, several projects were not surveyed until several years after they were constructed. Unfortunately, since the visual distress surveys were not performed on a consistent basis, summarizing and interpreting the data is difficult. For example, one may note that in Figures E-1 to E-9, some distresses appear to decrease with increasing age of pavement. For Figures E-1 to E-9, distresses were summarized according to the age of pavement. Since projects were constructed in different years and often not surveyed more than once or twice, each "age" does not include all projects. At one "age", distress data was often summarized for one set of projects, while at a different "age", another set of projects was summarized. This results in varying quantities of distresses from one age to another. Rather than compare one age of pavement to another, the point of Figures E-1 to E-9 is more for the reader to compare the quantities of distresses for the control, variable rate (dry process), fixed rate (dry process), and fixed rate (wet process) at one particular age of pavement.

One may also note that in Figures F-1 to F-66, some distresses decrease with increasing age within one particular project. There are two explanations for this inconsistency. One explanation is human subjectivity. What one surveyor noted during one survey, another surveyor may have missed or labeled differently during a later survey. Another explanation for the inconsistency could be that the length surveyed was not always consistent from one year to another. For example, in Projects C – H, more length was surveyed in 1998 than in 1997 (see Table 8). While Figures F-1 - F-66 show distresses according to length or number per mile, a larger total length surveyed does not necessarily mean one will find more of a particular distress. If one finds the same quantity of a distress as was found in an earlier year but a larger total length was surveyed, a smaller quantity per mile of that particular distress results.

Two particular distresses that decreased in some of the projects from one year to the next year were longitudinal and transverse cracking. It is important to understand that as longitudinal and transverse cracks increase and begin to connect, they are rated as block cracks. Therefore, as block cracking increases from one year to the next, there is a corresponding decrease in transverse and longitudinal cracking. For example, this is evident in the data in years 4 to 5 in Project E (Figures F-28, F-31 and F-33) and years 3 to 4 in Project H (Figures F-47, F-50, and F-53).

Based on all the data summarized in Tables 7 - 10 and Appendix E and F, some general conclusions can be drawn on the performance of the control, variable rate (dry method), fixed rate (dry method), and fixed rate (wet method) sections. The visual survey data summarized in the tables and figures indicate that the fixed rate (wet method) sections contained the lowest quantities of distresses overall. The experimental sections rank in the following order from best overall performance to worst: fixed rate (wet method), control, variable rate (dry method), and fixed rate (dry method).

The ranking was determined by a general analysis. In Tables 7 – 10, the sections were compared by year. Overall, it was found that for most years included in the tables, the fixed rate (dry) sections contained more distresses than the other sections. The control and variable rate (dry) sections compared very closely in the quantities of distresses per year, while the fixed rate (wet) sections appeared to have the least amount of distresses. In Figures E-1 to E-9, the sections were compared by year according to the quantity of distresses. Overall, in most years, the fixed rate (dry) sections contained a larger quantity of most of the distresses than the other sections. The control and variable rate (dry) sections were close in the quantities of distresses in most years, but the control sections had slightly more distresses in some years than the variable rate (dry) sections. Again, the fixed rate (wet) sections had the least amount of distresses in most years.

In Figures F-1 to F-66, the various sections were compared in each individual project. For example, Project A (see Figures F-1 to F-8) contains control and fixed rate (dry) sections. As seen in most of the figures for Project A, if the control and fixed rate (dry) sections did not contain equal quantities of distresses, the fixed rate (dry) sections contained more distresses than the control sections. For the projects like Project A that contain control and fixed rate (dry) sections (Projects A, D, and I), the figures show that the fixed rate (dry) sections usually contained more distresses than the control sections. For the projects that contain control and variable rate (dry) sections (Projects E, F, and G), the figures show that the variable rate (dry) sections usually contained more distresses than the control sections. In Project B, which is the one project that contains control and fixed rate (wet) sections, the control sections usually contained more distresses than the fixed rate (wet) sections. For Project K, which is the only project surveyed that contains control, fixed rate (dry) sections, and variable rate (dry) sections, the sections rank in the following order according to the smallest amount of distresses to the greatest (1) control (2) variable rate (dry) (3) fixed rate (dry). Projects C and H contain fixed rate (dry) sections only and no control sections. Therefore, no comparison could be made for those projects.

In conclusion, according to the graphical representations of the individual projects included in Appendix F, the control sections generally had lower quantities of distresses than the CRM sections. However, in Project B the fixed rate (wet method) sections generally contained fewer distresses than the control sections.

REFLECTIVE CRACKING

Modifying an HMA mix with CRM reportedly increases the resilience of the mix to reflective cracking. According to the report titled *Design and Construction of Asphalt Paving Materials with Crumb Rubber Modifier,* a CRM modified binder (produced by the wet process) "demonstrates a significant enhancement in laboratory elasticity and resilient modulus testing". According to the same report, "CRM, as rubber aggregate [produced by the dry process], may resist the stresses which occur as cracks in the existing pavement propagate upward through the overlay" [6].

Visual distress surveys were completed on Projects A and B shortly before the surface was paved with rubberized asphalt and conventional HMA (no CRM). Table 11 summarizes the amount of reflective cracking found in each distress survey of Projects A and B. Since no pre-construction surveys were completed for Projects C – K, reflective cracking could not be determined for those projects. For Projects A and B, post-construction surveys were compared to pre-construction surveys in order to determine the amount of reflective cracking. Transverse and longitudinal cracks in the post-construction surveys that matched cracks in the pre-construction surveys were tallied. A percentage was calculated by dividing the amount of reflective cracking in each post-construction survey by the amount of cracking in the original pavement surface (shown in the pre-construction survey).

Table 11 summarizes the amount and percentage of reflective transverse and longitudinal cracks for the control and rubberized asphalt test sections in Projects A and B. In Project A, fewer reflective cracks were found in the control sections than in the rubberized asphalt sections. However, in Project B, the percentage of reflective cracking in the rubberized asphalt sections was significantly lower than the percentage in the control sections. For Project B, the wet process was used to combine CRM with HMA. For Project A, the dry process was used. In comparing Projects A and B, it appears that the wet process is more effective than the dry process in producing a modified HMA mixture resilient to reflective cracking. Unfortunately, Project B was the only project in which the wet process was used to combine CRM with HMA. Therefore, the conclusion that the wet process reduces reflective cracking can not be further validated by more data. Furthermore, since pre-construction surveys were not completed on any other projects, data is not available for supporting the conclusion that the dry process does not appear to reduce reflective cracking.

SURFACE PROPERTY TESTING

Friction Testing

Treaded and smooth tire friction tests were performed on the rubberized asphalt pavements at various times between 1994 and 1999. The treaded tire friction numbers are collected to indicate microtexture, which is the fine-scale roughness of the pavement. The smooth tire friction numbers are collected to measure the drainage capability of the surface, also referred to as the macrotexture. Treaded and smooth tire friction test results with dates of testing are included in Table 12. Bar graphs of the average friction numbers are included in Appendix G: Figure G-1 (treaded tire) and Figure G-2 (smooth tire). In Figures G-1 and G-2, average friction numbers are indicated according to the type of section within the projects (control, variable rate (dry method), fixed rate (dry method), and fixed rate (wet method)) and the age of the projects at the time of testing. This was done in order to facilitate a better comparison between the various test sections at a particular age.

According to Table 12 and the figures in Appendix G, the average treaded tire friction numbers in most of the sections containing CRM were equivalent to the average treaded tire friction numbers measured in the control sections. However, the average smooth tire friction numbers were slightly higher in the fixed rate (dry method) sections than the average smooth tire friction numbers measured in the other CRM sections and the control sections. One exception as seen in Figure G-2 is that the fixed rate (dry method) sections in seven-year old pavements (the oldest pavements tested) had a slightly lower average smooth tire friction number than the control sections.

According to the department's rating guidelines for friction numbers found in Table 13, all the treaded and smooth tire friction numbers tested in the rubberized asphalt projects were within an acceptable range of friction numbers.

Ride Quality Testing

Ride quality testing was conducted in March 1999 using a road profiler, which measures surface roughness in inches per mile and rutting in inches. From the data collected with the road profiler, the International Roughness Index (IRI) and rutting values are calculated [7]. Table 14 contains the average IRI and rutting values with dates of testing.

IL 76 (Project J) was not tested for friction numbers or IRI and RUT values. As mentioned earlier in this report, sections containing CRM in Project J were paved only in the shoulder, while the mainline was paved with conventional HMA. Therefore, testing with the equipment in the shoulders would have been difficult, if not impossible. Furthermore, since traffic loading would have been significantly different between the experimental sections in Project J and the other projects, an accurate comparison could not have been made.

Table 14 includes IRI and rutting values for a total of ten projects, Projects A – I, and K. For the majority of those projects, IRI and rutting values were obtained in each of the CRM sections, as well as the control sections. Since Projects C and H contained no control sections, only IRI and rutting values are given for the CRM sections included in Projects C and H.

The department uses the following guidelines in evaluating IRI values:

IRI Range (Inches/Mile)	Smoothness
Below 60	Excellent
100 – 110	Fair
Over 175	Poor

No general statements can be made about the IRI values for the CRM sections versus the control sections. All the IRI values were between 63 and 184 inches per mile.

For rut values, the department becomes concerned if the rut value exceeds 0.3 inches. As seen in Table 14, all the rut values were in the range of 0.02 – 0.14 inches, which is well below 0.3 inches. No significant differences were found between the rut values of the CRM and control sections.

SUMMARY AND CONCLUSIONS

Between 1991 and 1995, eleven HMA paving projects were completed in Illinois with the addition of various quantities of CRM. The performance of these projects is a very important issue due to the environmental impact of utilizing recycled tire rubber in HMA.

In addition to cost information, the performance monitoring of the rubberized asphalt pavements in Illinois is summarized in this report. Performance data collected on the pavements include visual distress surveys and surface property measurements (friction numbers and ride quality).

Conclusions based on the cost and performance data are as follows:

1. On average, the HMA mix containing CRM for all the rubberized asphalt projects was 30% higher in cost than conventional HMA.
2. The one project in which the CRM and HMA were mixed by the wet process was 101% higher in cost than conventional HMA.
3. The cost for using CRM ranged from $0.28 to $5.30 per pound of CRM utilized.
4. On average, the CRM mix used in projects where the CRM and HMA were mixed by the dry process was 17% higher in cost than conventional HMA.
5. Based on the visual survey data, the sections rank in the following order from best overall performance to worst: fixed rate (wet method), control (no CRM), variable rate (dry method), and fixed rate (dry method).
6. According to the limited amount of pre-construction distress survey data available, the wet process appeared to be more effective than the dry process in producing a modified HMA mixture resilient to reflective cracking.
7. According to the Department's rating guidelines for friction numbers, all the treaded and smooth tire friction numbers collected in the rubberized asphalt projects (both the CRM and control sections) were within an acceptable range of friction numbers.

8. The IRI values for the CRM and control sections were within a range of 63 to 184 inches per mile. No substantial difference in the IRI values was evident between the CRM and control sections.
9. The rut values for the CRM and control sections were in the range of 0.02 – 0.14 inches, which is well below the department's acceptable limit. Again, no substantial difference in the rut values was noted between the CRM and control sections.

Table 1. Rubberized Asphalt Pavements in Illinois

Project Designation	Marked Route	Contract Number	District	County	Location	Year of Construction	Wet / Dry Process	Fixed / Variable Rate
A	US 67 / IL 100	92443	6	Morgan	Northeast of Meredosia	1991	Dry	Fixed
B	IL 1	94190	7	Lawrence	South of Lawrenceville	1992	Wet	Fixed
C	US 67 / IL 104	92714	6	Morgan	Southeast of Meredosia	1993	Dry	Fixed
D	IL 242	94327	7	Wayne & Hamilton	South of Wayne City	1993	Dry	Fixed
E	IL 116	88243	4	Fulton	East of Spoon River West of IL 97	1993	Dry	Variable
F	IL 107	92716	6	Brown	South of Mount Sterling	1993	Dry	Variable
G	IL 33	94191	7	Effingham	Between Beecher City and Shumway	1993	Dry	Variable
H	IL 91	88444	4	Peoria	Between Dunlap and US 150	1994	Dry	Fixed
I	US 14	82846	1	McHenry	South of Harvard	1995	Dry	Variable
J	IL 76	84469	2	Boone	North of Belvidere to Illinois/Wisconsin border	1995	Dry	Variable & Fixed
K	US 24	86596	3	Iroquois	Between Gilman and IL 49	1995	Dry	Variable & Fixed

Table 2. Rubberized Asphalt Pavements
Pavement Designs and Quantities of CRM

Project Designation	Contract Number	Pavement Design	Shoulder Design	Tons Surface Mix w/ CRM	Lbs CRM/ Ton of HMA	Tons CRM	# of Tires
A	92443	1½" surface (1991) over existing 5" bituminous on 9"-6"-9" PCC	Bituminous & Aggregate	4,000	24.0	48.0	8,870
B	94190	1½" surface (1992) over existing 3" bituminous on 9"-6"-9" PCC	Bituminous & Aggregate	2,400	36.0	43.2	7,850
C	92714	1½" surface over ¾" binder (1993) on existing 3 - 5" bituminous on 9"-6"-9" PCC	Bituminous & Aggregate	2,400	20.0	24.0	4,435
D	94327	1½" surface (1993) over existing 8" bituminous on 9"-6"-9" PCC	Aggregate	5,000	20.0	50.0	9,240
E	88243	1½" surface over ¾" binder (1993) on existing 2" bituminous on 9"-6"-9" PCC or 9" PCC base course	Bituminous & Aggregate	10,000	0.5 - 2.0	5.0	924
F	92716	1½" surface over ¾" binder (1993) on existing 3" bituminous on 16" crushed stone with A-3 surface treatment	Bituminous & Aggregate	5,000	0.5 - 2.0	2.5	462
G	94191	1½" surface over ¾" binder (1993) on existing 2.25" bituminous on 9"-7"-9" PCC	Bituminous & Aggregate	5,000	0.5 - 2.0	2.5	402
H	88444	1½" surface (1994) over existing 3.75" - 6" bituminous on 9"-7"-9" PCC	Bituminous & Aggregate	3,100	20.0	31.0	5,000
I	82846	1½" surface (1995) over existing 4.5" bituminous on 10" PCC	Aggregate	1,300	5.0	3.3	600
J	84469	1½" surface over ¾" - 1" binder (1995) over 8½" - 11½" bituminous on 9"-6"-9" or 9"-7"-9" PCC	Bituminous & Aggregate	2,600*	4.0 - 6.0 & 20.0	15.3	2,825
K	86596	1½" surface over 0 - 1¾" binder (1995) on existing 0 - 3" bituminous on 10" PCC	Bituminous & Aggregate	4,396 2,597*	4.0 - 6.0 & 20.0	54.0	10,000

*Tons Binder Mix

Table 3. Rubberized Asphalt Pavements
Lengths of Experimental Sections

Marked Route	Contract Number	Total Length Lane-Miles	Length of Sections (Lane-Miles)			
			Control	Variable Rate (Dry)	Fixed Rate (Dry)	Fixed Rate (Wet)
US 67 / IL 100	92443	6.30	1.56	---	4.74	---
IL 1	94190	20.24	16.41	---	---	3.83
US 67 / IL 104	92714	2.80	---	---	2.80	---
IL 242	94327	35.76	8.00	---	26.76	---
IL 116	88243	13.44	2.29	11.15	---	---
IL 107	92716	7.92	1.16	6.76	---	---
IL 33	94191	20.86	14.54	6.32	---	---
IL 91	88444	4.68	1.01	---	3.67	---
US 14	82846	5.60	2.80	2.80	---	---
IL 76	84469	30.80 (mainline)	30.80 (mainline)	0.60 (shoulder)	0.50 (shoulder)	---
US 24	86596	13.06	4.76	2.80	5.50	---

Table 4. Rubberized Asphalt Pavements Cost Comparisons

Project Designation	Contract Number	District	Year of Construction	Fixed / Variable Rate	Cost / Ton of HMA with CRM	Material Used for Comparison	Cost / Ton Conventional HMA (Used in Projects)	Percent Increase in Cost	Tons CRM	Cost Rate** $/lb CRM
A	92443	6	1991	Fixed	$34.66	Class I, Type 2, C Surface Mix	$23.45	52%	48.0	$0.47
B	94190	7	1992	Fixed	$80.00	Class I, Type 2, D Surface Mix	$39.90	101%	43.2	$1.11
C	92714	6	1993	Fixed	$38.66	Class I, Type 2, C Surface Mix	$32.66*	19%	24.0	$0.30
D	94327	7	1993	Fixed	$39.90	Class I, Type 2, D Surface Mix	$32.30	24%	50.0	$0.38
E	88243	4	1993	Variable	$36.63	Class I, Type 2, D Surface Mix	$30.00	22%	5.0	$5.30
F	92716	6	1993	Variable	$31.36	Class I, Type 2, C Surface Mix	$29.62	6%	2.5	$1.39
G	94191	7	1993	Variable	$39.76	Class I, Type 2, C Surface Mix	$33.20	20%	2.5	$5.25
H	88444	4	1994	Fixed	$51.60	Class I, Type 2, D Surface Mix	$36.00*	43%	31.0	$0.78
I	82846	1	1995	Variable	$30.75	Class I, Type 2, D Surface Mix	$28.90	6%	3.3	$0.37
J	84469	2	1995	Variable & Fixed	$35.15	Class I, Type 2, B Binder Mix	$28.66	23%	15.3	$0.52
K	86596	3	1995	Variable & Fixed	$40.00	Class I, Type 2, B Binder Mix	$34.50	16%	26.0	$0.28
					$44.00	Class I, Type 2, D Surface Mix	$35.00	24%	28.0	$0.60

*For Projects C and H, no costs were available for conventional HMA. Instead, a typical cost of conventional mix provided by the same contractor that provided the HMA with CRM is given for these projects.

**For all jobs using CRM, the average cost was $0.50/lb. for the dry process and $1.11/lb. for the wet process

Table 5. Rubberized Asphalt Pavements
Traffic Data
(Averages from Year of Construction to 1999)

Project Designation	Marked Route	Contract Number	Year of Construction	PV	SU	MU	ESALs/ Year	Cumulative ESALs
A	US 67 / IL 100	92443	1991	2,076	163	299	0.12	0.93
B	IL 1	94190	1992	2,973	180	174	0.07	0.52
C	US 67 / IL 104	92714	1993	3,525	151	358	0.14	0.81
D	IL 242	94327	1993	1,198	67	62	0.03	0.16
E	IL 116	88243	1993	1,300	77	161	0.06	0.37
F	IL 107	92716	1993	1,149	84	151	0.06	0.35
G	IL 33	94191	1993	2,889	100	126	0.05	0.31
H	IL 91	88444	1994	2,388	178	178	0.07	0.37
I	US 14	82846	1995	8,337	288	471	0.19	0.74
J	IL 76	84469	1995	5,248	183	575	0.21	0.86
K	US 24	86596	1995	3,252	131	497	0.18	0.73

Table 6. Rubberized Asphalt Pavements
Total Miles Surveyed

Project Designation	Year of Construction	Types of Sections in Project	Total Miles Surveyed							
			1991	1992	1993	1994	1995	1996	1997	1998
A	1991	Control	0.75*	0.75	0.75	---	---	---	---	1.42
		Fixed Rate (Dry)	0.38*	0.38	0.38	---	---	---	---	0.86
B	1992	Control	---	1.14*	1.14	---	---	---	1.14	1.14
		Fixed Rate (Wet)	---	0.38*	0.38	---	---	---	0.38	0.38
C	1993	Fixed Rate (Dry)	---	---	---	---	---	---	0.95	2.27
D	1993	Control	---	---	---	---	---	---	0.57	1.14
		Fixed Rate (Dry)	---	---	---	---	---	---	0.76	2.27
E	1993	Control	---	---	---	---	---	---	0.05	0.05
		Variable Rate	---	---	---	---	---	---	1.00	1.95
F	1993	Control	---	---	---	---	---	---	0.28	0.62
		Variable Rate	---	---	---	---	---	---	0.76	1.47
G	1993	Control	---	---	---	---	---	---	0.38	0.76
		Variable Rate	---	---	---	---	---	---	0.76	1.52
H	1994	Fixed Rate (Dry)	---	---	---	---	---	---	1.08	2.02
I	1995	Control	---	---	---	---	---	---	---	0.76
		Variable Rate	---	---	---	---	---	---	---	0.76
J	1995	Control	---	---	---	---	---	---	---	---
		Fixed Rate (Dry)	---	---	---	---	---	---	---	---
		Variable Rate	---	---	---	---	---	---	---	---
K	1995	Control	---	---	---	---	---	---	---	0.95
		Fixed Rate (Dry)	---	---	---	---	---	---	---	0.95
		Variable Rate	---	---	---	---	---	---	---	0.38

* indicates pre-construction distress survey

Table 7. Rubberized Asphalt Pavements
Summary of Visual Distress Surveys
Control Sections

Distress	Severity	Units[ab]	Age of Pavement (Years) 1	2	3	4	5	6	7
Length Surveyed	-	Miles Surveyed	1.9	0.8	1.7	1.3	3.7	1.1	1.4
Alligator Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0	0.0	0.0	1,466.9
	Medium		0.0	0.0	0.0	0.0	0.0	0.0	90.1
	High		0.0	0.0	0.0	0.0	0.0	0.0	21.8
Bleeding	-	Lane Feet/Mile	0.0	0.0	84.7	0.0	21.1	0.0	0.0
Block Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	110.1	51.4	0.0	0.0
	Medium		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Center of Lane Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	32.6	77.0	269.3	1,707.0
	Medium		0.0	0.0	0.0	0.0	0.0	0.0	11.3
	High		0.0	0.0	0.0	0.0	0.0	0.0	17.6
Centerline Cracking	Low	Lane Feet/Mile	213.8	2,629.3	2,647.1	1,523.3	2,266.2	2,631.6	2,614.8
	Medium		0.0	24.0	0.0	0.0	0.0	0.0	19.0
	High		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Longitudinal Cracking	Low	Lane Feet/Mile	0.0	30.7	14.7	109.3	177.3	97.4	1,102.1
	Medium		0.0	0.0	0.0	0.0	0.0	0.0	143.7
	High		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Overlaid Patch Deterioration	Low	Square Feet/Mile	114.3	752.0	112.9	0.0	38.9	273.7	752.1
	Medium		0.0	0.0	0.0	0.0	0.0	136.8	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Potholes	Low	Number/Mile	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Medium		0.0	0.0	0.0	0.0	0.3	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raveling	Low	Lane Feet/Mile	0.0	0.0	5,294.1	3,488.4	5,206.2	5,263.2	5,203.5
	Medium		0.0	0.0	0.0	0.0	0.0	0.0	64.1
	High		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Reflected Patch Joint Cracking	Low	Number/Mile	0.0	0.0	2.4	0.0	1.1	12.3	24.6
	Medium		0.0	0.0	0.0	0.0	0.0	0.0	2.1
	High		0.0	0.0	0.6	0.0	0.0	0.0	0.0
Transverse Cracking	Low	Number/Mile	25.9	121.3	118.2	73.6	92.7	104.4	193.7
	Medium		5.3	5.3	1.2	0.0	3.0	8.8	43.0
	High		0.0	0.0	5.9	0.0	1.1	6.1	0.7

[a] Miles are total one-lane miles of projects at that age

[b] Values are calculated by dividing the total quantities by the number of one-lane miles at that age, except for centerline cracking which is divided by the number of two-lane miles; i.e. bleeding at three years of age equals 84.7 feet per one-lane mile.

Table 8. Rubberized Asphalt Pavements
Summary of Visual Distress Surveys
Variable Rate Sections

Distress	Severity	Units[ab]	Age of Pavement (Years)				
			1	2	3	4	5
Length Surveyed	-	Miles Surveyed	0.0	0.0	1.1	2.5	4.9
Alligator Cracking	Low	Lane Feet/Mile	0.0	0.0	707.0	0.0	0.0
	Medium		0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0
Bleeding	-	Lane Feet/Mile	0.0	0.0	0.0	0.0	19.2
Block Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	423.8	1,618.6
	Medium		0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0
Center of Lane Cracking	Low	Lane Feet/Mile	0.0	0.0	101.8	139.7	36.4
	Medium		0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0
Centerline Cracking	Low	Lane Feet/Mile	0.0	0.0	2,631.6	2,596.8	2,617.6
	Medium		0.0	0.0	0.0	39.7	20.2
	High		0.0	0.0	0.0	0.0	0.0
Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	148.2	467.1	291.3
	Medium		0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0
Overlaid Patch Deterioration	Low	Square Feet/Mile	0.0	0.0	631.6	0.0	48.6
	Medium		0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0
Potholes	Low	Number/Mile	0.0	0.0	0.0	0.0	3.8
	Medium		0.0	0.0	0.0	0.0	1.4
	High		0.0	0.0	0.0	0.0	0.0
Raveling	Low	Lane Feet/Mile	0.0	0.0	5,263.2	2,381.0	5,217.4
	Medium		0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0
Reflected Patch Joint Cracking	Low	Number/Mile	0.0	0.0	6.1	0.0	1.2
	Medium		0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	8.8	0.0	0.0
Transverse Cracking	Low	Number/Mile	0.0	0.0	137.7	102.4	70.4
	Medium		0.0	0.0	0.0	0.0	1.2
	High		0.0	0.0	14.0	0.0	3.6

[a] Miles are total one-lane miles of projects at that age

[b] Values are calculated by dividing the total quantities by the number of one-lane miles at that age, except for centerline cracking which is divided by the number of two-lane miles; i.e. low severity alligator cracking at three years of age equals 707.0 feet per one-lane mile.

Table 9. Rubberized Asphalt Pavements
Summary of Visual Distress Surveys
Fixed Rate (Dry Method) Sections

Distress	Severity	Units[ab]	Age of Pavement (Years)						
			1	2	3	4	5	6	7
Length Surveyed	-	Miles Surveyed	0.4	0.4	2.0	3.7	3.8	0.0	0.9
Alligator Cracking	Low	Lane Feet/Mile	0.0	0.0	4.9	98.4	8.4	0.0	3,195.3
	Medium		0.0	0.0	0.0	102.9	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bleeding	-	Lane Feet/Mile	0.0	0.0	0.0	19.3	21.6	0.0	0.0
Block Cracking	Low	Lane Feet/Mile	0.0	0.0	465.0	1,281.8	0.0	0.0	96.5
	Medium		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Center of Lane Cracking	Low	Lane Feet/Mile	0.0	0.0	28.1	159.5	267.5	0.0	12.8
	Medium		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Centerline Cracking	Low	Lane Feet/Mile	0.0	2,657.9	2,641.4	2,498.4	2,583.9	0.0	2,619.8
	Medium		0.0	0.0	0.0	0.0	0.0	0.0	8.1
	High		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	1,059.6	980.2	2,114.8	0.0	1,247.7
	Medium		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	14.8	0.0	0.0	0.0	0.0
Overlaid Patch Deterioration	Low	Square Feet/Mile	0.0	2,463.2	413.8	0.0	0.0	0.0	1,869.8
	Medium		0.0	0.0	0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Potholes	Low	Number/Mile	0.0	0.0	0.5	0.3	0.0	0.0	4.7
	Medium		0.0	0.0	1.0	0.8	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raveling	Low	Lane Feet/Mile	0.0	0.0	5,282.8	4,702.7	5,245.1	0.0	5,150.0
	Medium		0.0	26.3	0.0	39.4	31.9	0.0	105.8
	High		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Reflected Patch Joint Cracking	Low	Number/Mile	0.0	0.0	2.5	0.0	0.0	0.0	30.2
	Medium		0.0	0.0	0.0	0.0	0.0	0.0	14.0
	High		0.0	0.0	4.4	0.0	0.0	0.0	1.2
Transverse Cracking	Low	Number/Mile	0.0	94.7	171.9	158.2	127.4	0.0	197.7
	Medium		0.0	36.8	3.9	12.1	9.0	0.0	2.3
	High		0.0	2.6	14.8	0.5	0.0	0.0	3.5

[a] Miles are total one-lane miles of projects at that age

[b] Values are calculated by dividing the total quantities by the number of one-lane miles at that age, except for centerline cracking which is divided by the number of two-lane miles; i.e. low severity alligator cracking at three years of age equals 4.9 feet per one-lane mile.

Table 10. Rubberized Asphalt Pavements
Summary of Visual Distress Surveys
Fixed Rate (Wet Method) Sections

Distress	Severity	Units[ab]	Age of Pavement (Years)					
			1	2	3	4	5	6
Length Surveyed	-	Miles Surveyed	0.4	0.0	0.0	0.0	0.4	0.4
Alligator Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0	0.0	0.0
	Medium		0.0	0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0
Bleeding	-	Lane Feet/Mile	0.0	0.0	0.0	0.0	0.0	0.0
Block Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0	0.0	0.0
	Medium		0.0	0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0
Center of Lane Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0	47.4	52.6
	Medium		0.0	0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0
Centerline Cracking	Low	Lane Feet/Mile	113.2	0.0	0.0	0.0	2,631.6	2,631.6
	Medium		0.0	0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0
Longitudinal Cracking	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0	0.0	0.0
	Medium		0.0	0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0
Overlaid Patch Deterioration	Low	Square Feet/Mile	0.0	0.0	0.0	0.0	0.0	0.0
	Medium		0.0	0.0	0.0	0.0	0.0	157.9
	High		0.0	0.0	0.0	0.0	0.0	0.0
Potholes	Low	Number/Mile	0.0	0.0	0.0	0.0	0.0	0.0
	Medium		0.0	0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0
Raveling	Low	Lane Feet/Mile	0.0	0.0	0.0	0.0	5,263.2	5,263.2
	Medium		0.0	0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0
Reflected Patch Joint Cracking	Low	Number/Mile	0.0	0.0	0.0	0.0	0.0	5.3
	Medium		0.0	0.0	0.0	0.0	0.0	0.0
	High		0.0	0.0	0.0	0.0	0.0	0.0
Transverse Cracking	Low	Number/Mile	21.1	0.0	0.0	0.0	86.8	92.1
	Medium		2.6	0.0	0.0	0.0	10.5	10.5
	High		0.0	0.0	0.0	0.0	0.0	2.6

[a] Miles are total one-lane miles of projects at that age

[b] Values are calculated by dividing the total quantities by the number of one-lane miles at that age, except for centerline cracking which is divided by the number of two-lane miles; i.e. low severity center of lane cracking at five years of age equals 47.4 feet per one lane mile.

Table 11. Rubberized Asphalt Pavements
Reflective Cracking Summary

Section	Age of Pavement	Transverse Cracks		Longitudinal Cracks	
		Number	% Cracks Reflected	Lane-feet	% Cracks Reflected
Project A					
Crumb Rubber Sections	0 (Pre-construction)	90	-	2,432	-
(2020 ft. surveyed)	2 years	40	44.4	0	0
	7 years	87	96.7	1,177	48.4
Control Sections	0 (Pre-construction)	192	-	3,481	-
(3980 ft. surveyed)	2 years	83	43.2	0	0
	7 years	179	93.2	1,656	47.6
Project B					
Crumb Rubber Sections	0 (Pre-construction)	49	-	182	-
(2000 ft. surveyed)	1 year	9	18.4	0	0
	5 years	34	69.4	18	9.9
	6 years	39	79.6	20	11.0
Control Sections	0 (Pre-construction)	145	-	2,417	-
(6000 ft. surveyed)	1 year	58	40.0	0	0
	5 years	132	91.0	281	11.6
	6 years	136	93.8	318	13.2

Table 12. Rubberized Asphalt Pavements
Friction Data

Project Designation	Marked Route	Contract Number	Types of Sections Tested	Direction	Test Date	Friction Number	
						FNt	FNs
A	US 67 / IL 100	92443	Control	Northbound	10/11/94	55	46
					9/30/96	47	41
					5/19/98	48	44
			Fixed Rate (Dry)	Northbound	10/11/94	52	41
					9/30/96	45	35
					5/19/98	47	39
			Fixed Rate (Dry)	Southbound	10/11/94	54	43
					9/30/96	48	41
					5/19/98	49	43
B	IL 1	94190	Control	Southbound	10/13/94	50	31
					9/29/97	46	29
					8/4/98	47	31
			Fixed Rate (Wet)	Southbound	10/13/94	50	35
					9/29/97	50	32
					8/4/98	52	37
C	US 67 / IL 104	92714	Fixed Rate (Dry)	Westbound	10/11/94	55	45
					8/28/96	40	32
					5/19/98	49	45
			Fixed Rate (Dry)	Eastbound	10/11/94	55	42
					8/28/96	48	35
					5/19/98	51	40
D	IL 242	94327	Control	Northbound	10/14/94	58	44
					5/24/95	60	40
					9/29/97	55	42
					8/5/98	57	41
			Control	Southbound	10/14/94	51	38
					5/24/95	58	31
					9/29/97	51	32
					8/5/98	51	29

Table 12. Rubberized Asphalt Pavements
Friction Data Continued

Project Designation	Marked Route	Contract Number	Types of Sections Tested	Direction	Test Date	Friction Number	
						FNt	FNs
D	IL 242	94327	Fixed Rate (Dry)	Northbound	10/14/94	56	44
					5/24/95	57	40
					9/29/97	54	41
					8/5/98	55	39
					10/14/94	53	49
					5/24/95	58	43
					9/29/97	53	49
					8/5/98	55	46
			Fixed Rate (Dry)	Southbound	10/14/94	53	49
					5/24/95	59	43
					9/29/97	52	48
					8/5/98	55	50
E	IL 116	88243	Control	Westbound	10/12/94	51	24
					9/25/97	49	31
					6/29/98	51	37
			Variable Rate - 0.5 lb/ton	Westbound	10/12/94	53	31
					9/25/97	54	38
					6/29/98	57	39
			Variable Rate - 1.0 lb/ton	Westbound	10/12/94	56	34
					9/25/97	56	38
					6/29/98	58	43
			Variable Rate - 1.5 lb/ton	Eastbound	10/12/94	53	29
					9/25/97	51	34
					6/29/98	54	41
			Variable Rate - 2.0 lb/ton	Eastbound	10/12/94	55	32
					9/25/97	52	37
					6/29/98	55	39
F	IL 107	92716	Control	Southbound	10/11/94	51	31
					9/18/95	44	30
					9/5/97	41	28
					6/25/98	41	31

Table 12. Rubberized Asphalt Pavements
Friction Data Continued

Project Designation	Marked Route	Contract Number	Types of Sections Tested	Direction	Test Date	Friction Number FNt	Friction Number FNs
F	IL 107	92716	Variable Rate - 0.5 lb/ton	Northbound	10/11/94	54	28
					9/18/95	48	26
					9/5/97	50	26
					6/25/98	47	34
			Variable Rate - 1.0 lb/ton	Southbound	10/11/94	53	36
					9/18/95	47	30
					9/5/97	46	31
					6/25/98	43	35
			Variable Rate - 1.5 lb/ton	Northbound	10/11/94	52	29
					9/18/95	49	28
					9/5/97	48	29
					6/25/98	46	31
			Variable Rate - 2.0 lb/ton	Southbound	10/11/94	55	36
					9/18/95	50	33
					9/5/97	49	31
					6/25/98	47	36
G	IL 33	94191	Control	Eastbound	10/13/94	48	35
					5/22/95	52	31
					9/23/97	50	31
					6/8/98	49	34
			Variable Rate - 0.5 lb/ton	Eastbound	10/13/94	52	37
					5/22/95	57	41
					9/23/97	53	32
					6/8/98	54	35
			Variable Rate - 1.0 lb/ton	Eastbound	10/13/94	49	33
					5/22/95	54	33
					9/23/97	51	32
					6/8/98	51	30
			Variable Rate - 1.5 lb/ton	Westbound	10/13/94	53	40
					5/22/95	60	40
					9/23/97	56	33
					6/8/98	56	36

**Table 12. Rubberized Asphalt Pavements
Friction Data Continued**

Project Designation	Marked Route	Contract Number	Types of Sections Tested	Direction	Test Date	Friction Number FNt	Friction Number FNs
G	IL 33	94191	Variable Rate - 2.0 lb/ton	Westbound	10/13/94	55	41
					5/22/95	60	40
					9/23/97	56	35
					6/8/98	57	36
H	IL 91	88444	Fixed Rate (Dry)	Northbound	10/12/94	48	42
					8/1/96	52	42
					6/4/98	50	42
			Fixed Rate (Dry)	Southbound	10/12/94	44	38
					8/1/96	50	39
					6/4/98	50	44
I	US 14	82846	Variable Rate	Westbound	10/17/96	51	35
			Variable Rate	Eastbound	10/17/96	46	35

Table 13

Categorical Rating Guidelines for Friction Numbers*

Range of Friction Numbers	Tentative Guidelines
$Fn_t \le 30$ **or** $1 \le Fn_s \le 15$	Friction may be a factor contributing to wet weather accidents
$Fn_t > 30$ and $16 \le Fn_s \le 25$ **or** $31 \le Fn_t \le 35$ and $Fn_s > 25$	Uncertain if friction is a factor contributing to wet weather accidents
$Fn_t > 35$ **and** $Fn_s > 25$	Friction may not be a factor contributing to wet weather accidents

Fn_t = Treaded Tire Friction Numbers at 40 mph (64 kmph)

Fn_s = Smooth Tire Friction Numbers at 40 mph (64 kmph)

*Data Source: Testing Pavement Friction (PTA 96-4), Illinois Department of Transportation, Bureau of Materials and Physical Research

Table 14. Rubberized Asphalt Pavements
Ride Quality

Project Designation	Marked Route	Contract #	Types of Sections Tested	Direction	Test Date	Ride Quality IRI	Ride Quality RUT
A	US 67 / IL 100	92443	Control	Northbound	3/15/99	133	0.09
				Southbound	3/15/99	156	0.05
			Fixed Rate (Dry)	Northbound	3/15/99	161	0.08
				Southbound	3/15/99	138	0.06
B	IL 1	94190	Control	Northbound	3/22/99	82	0.09
				Southbound	3/22/99	87	0.07
			Fixed Rate (Wet)	Southbound	3/22/99	85	0.09
C	US 67 / IL 104	92714	Fixed Rate (Dry)	Eastbound	3/15/99	84	0.08
				Westbound	3/15/99	93	0.08
D	IL 242	94327	Control	Northbound	3/24/99	69	0.07
				Southbound	3/24/99	68	0.03
			Fixed Rate (Dry)	Northbound	3/24/99	72	0.08
				Southbound	3/24/99	70	0.05
E	IL 116	88243	Control	Eastbound	3/16/99	103	0.04
				Westbound	3/16/99	102	0.06
			Variable Rate - 0.5 lb/ton	Westbound	3/16/99	84	0.04
			Variable Rate - 1.0 lb/ton	Westbound	3/16/99	86	0.04
			Variable Rate - 1.5 lb/ton	Eastbound	3/16/99	81	0.05
				Westbound	3/16/99	84	0.04
			Variable Rate - 2.0 lb/ton	Eastbound	3/16/99	80	0.05
F	IL 107	92716	Control	Northbound	3/15/99	72	0.06
				Southbound	3/15/99	70	0.07
			Variable Rate - 0.5 lb/ton	Northbound	3/15/99	82	0.06
			Variable Rate - 1.0 lb/ton	Northbound	3/15/99	184	0.14
				Southbound	3/15/99	80	0.09
			Variable Rate - 1.5 lb/ton	Northbound	3/15/99	74	0.1
				Southbound	3/15/99	63	0.1
			Variable Rate - 2.0 lb/ton	Southbound	3/15/99	68	0.07

Table 14. Rubberized Asphalt Pavements
Ride Quality Continued

Project Designation	Marked Route	Contract #	Types of Sections Tested	Direction	Test Date	Ride Quality	
						IRI	RUT
G	IL 33	94191	Control	Eastbound	3/24/99	91	0.11
				Westbound	3/24/99	90	0.09
			Variable Rate - 0.5 lb/ton	Eastbound	3/24/99	87	0.09
			Variable Rate - 1.0 lb/ton	Eastbound	3/24/99	108	0.1
			Variable Rate - 1.5 lb/ton	Westbound	3/24/99	77	0.06
			Variable Rate - 2.0 lb/ton	Westbound	3/24/99	79	0.07
H	IL 91	88444	Fixed Rate (Dry)	Northbound	3/16/99	107	0.04
				Southbound	3/16/99	126	0.04
I	US 14	82846	Control	Westbound	3/17/99	97	0.03
			Variable Rate	Eastbound	3/17/99	90	0.03
K	US 24	86596	Control	Eastbound	3/17/99	76	0.07
				Westbound	3/17/99	81	0.03
			Fixed Rate - Conventional surface over 20 lb/ton binder	Eastbound	3/17/99	75	0.02
			Fixed Rate - 20 lb/ton surface over 20 lb/ton binder	Eastbound	3/17/99	94	0.03
			Fixed Rate - 20 lb/ton surface over conventional binder	Eastbound	3/17/99	84	0.02
			Fixed Rate - 5 lb/ton surface over conventional binder	Westbound	3/17/99	73	0.02

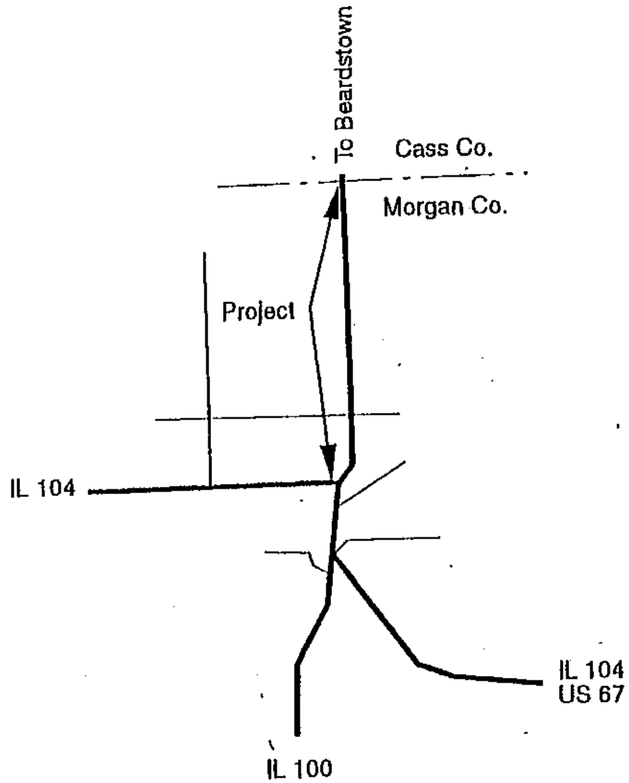
REFERENCES

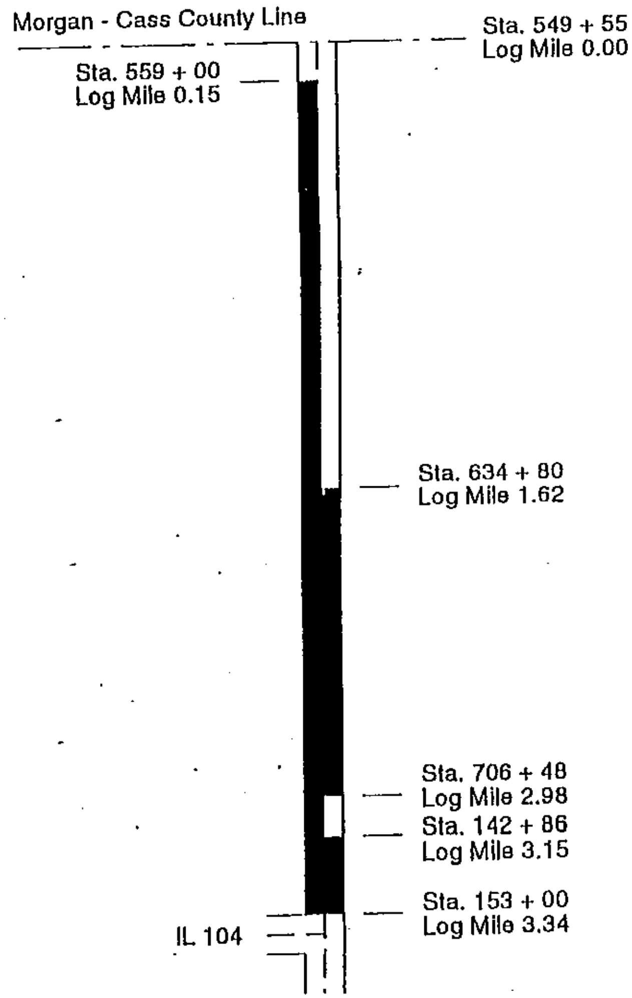
1. M. Heitzman, *State of the Practice - Design and Construction of Asphalt Paving Materials with Crumb Rubber Modifier,* Federal Highway Administration, Office of Engineering/Office of Technology Applications, Report No. FHWA/LA-92/215, May 1992, p. 5.
2. J. Trepanier, *Evaluation of Reclaimed Rubber in Bituminous Pavements,* Illinois Department of Transportation, Bureau of Materials and Physical Research, Physical Research Report No. 117, June 1995, p. 1.
3. M. Heitzman, *State of the Practice - Design and Construction of Asphalt Paving Materials with Crumb Rubber Modifier,* Federal Highway Administration, Office of Engineering/Office of Technology Applications, Report No. FHWA/LA-92/215, May 1992, p. 24 - 25.
4. J. Trepanier, *Evaluation of Reclaimed Rubber in Bituminous Pavements,* Illinois Department of Transportation, Bureau of Materials and Physical Research, Physical Research Report No. 117, June 1995, p. 1-3.
5. *Performance Monitoring of Mechanistically Designed Pavements*, Illinois Department of Transportation, Springfield, Illinois, April 1997, p. 4.
6. M. Heitzman, *State of the Practice - Design and Construction of Asphalt Paving Materials with Crumb Rubber Modifier,* Federal Highway Administration, Office of Engineering/Office of Technology Applications, Report No. FHWA/LA-92/215, May 1992, p. 19, 21.
7. *Performance Monitoring of Mechanistically Designed Pavements*, Illinois Department of Transportation, Springfield, Illinois, April 1997, p. 5.

APPENDIX A

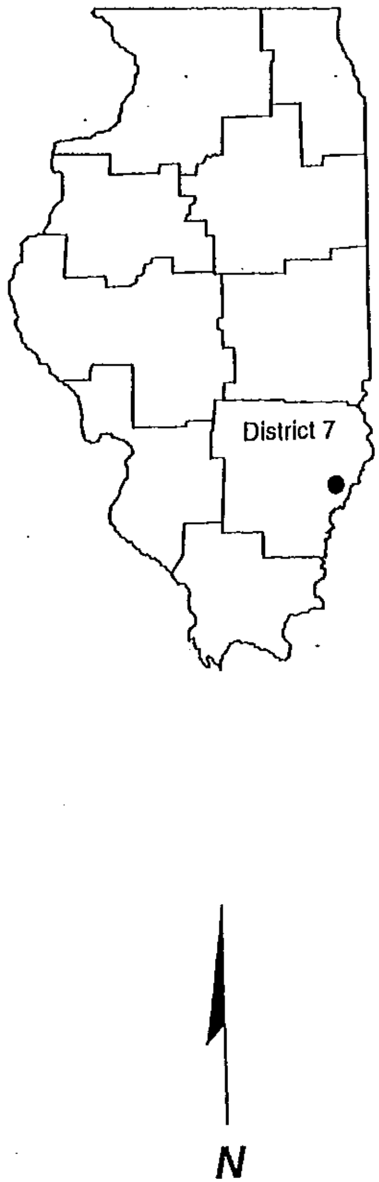
Project Maps

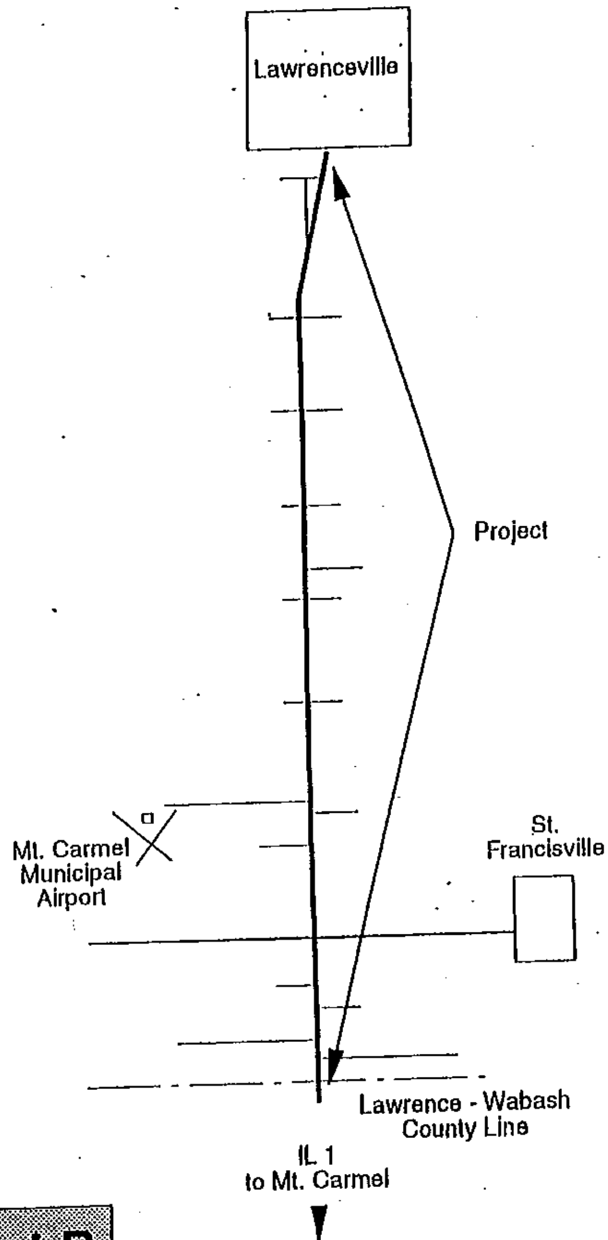

District 6
N

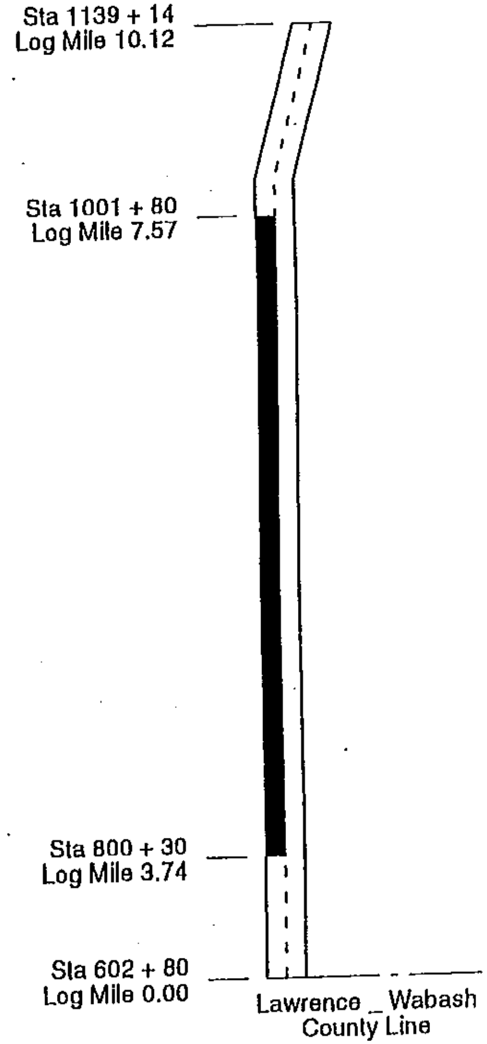

To Beardstown
Cass Co.
Morgan Co.
Project
IL 104
IL 104
US 67
IL 100


Morgan - Cass County Line
Sta. 549 + 55
Log Mile 0.00
Sta. 559 + 00
Log Mile 0.15
Sta. 634 + 80
Log Mile 1.62
Sta. 706 + 48
Log Mile 2.98
Sta. 142 + 86
Log Mile 3.15
Sta. 153 + 00
Log Mile 3.34
IL 104

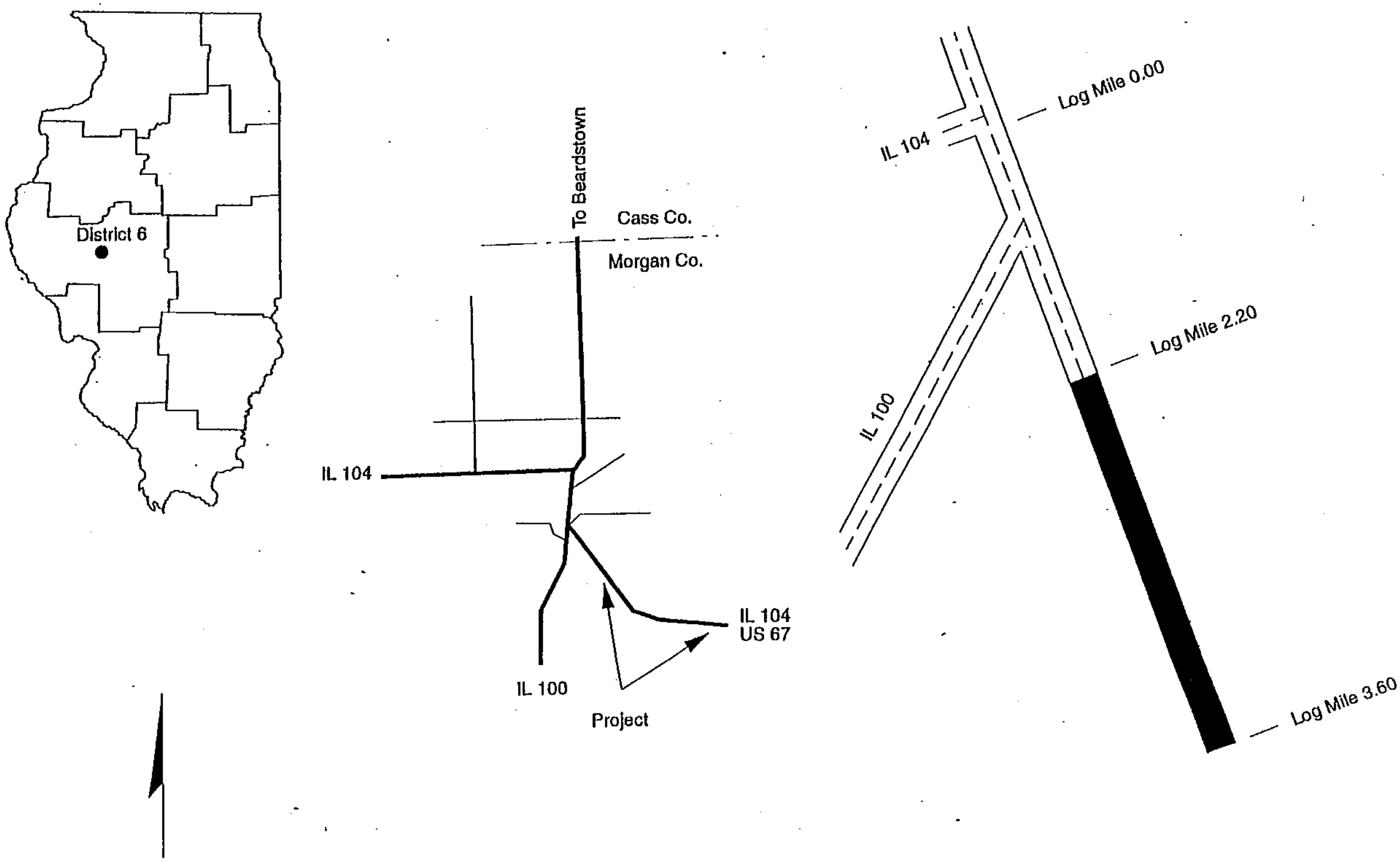
Project A


District 7
N

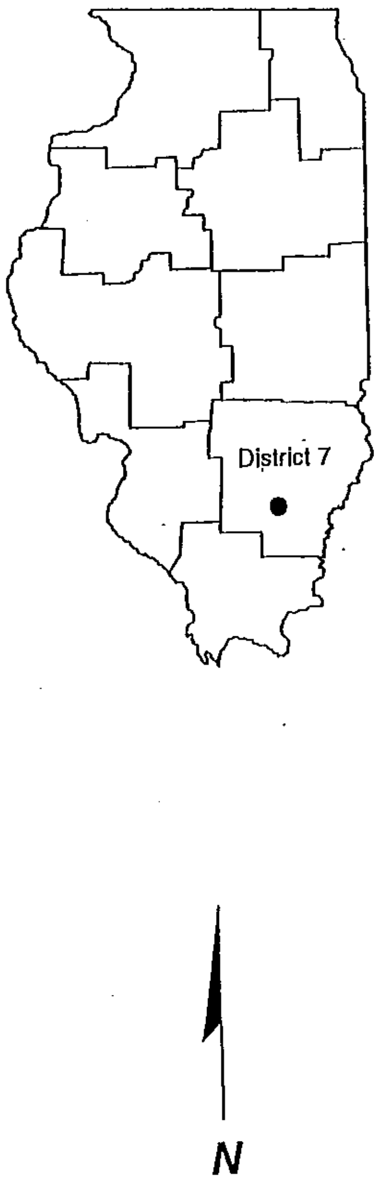

Lawrenceville
Project
Mt. Carmel
Municipal
Airport
St.
Francisville
Lawrence - Wabash
County Line
IL 1
to Mt. Carmel

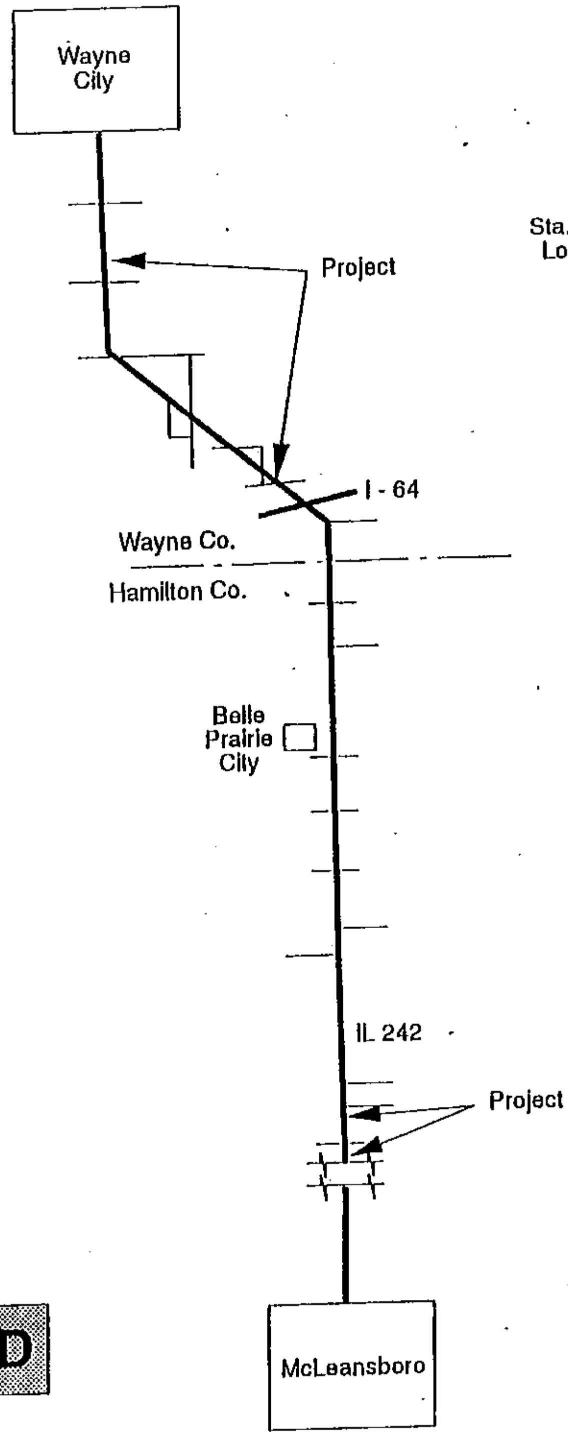

Sta 1139 + 14
Log Mile 10.12
Sta 1001 + 80
Log Mile 7.57
Sta 800 + 30
Log Mile 3.74
Sta 602 + 80
Log Mile 0.00
Lawrence _ Wabash
County Line

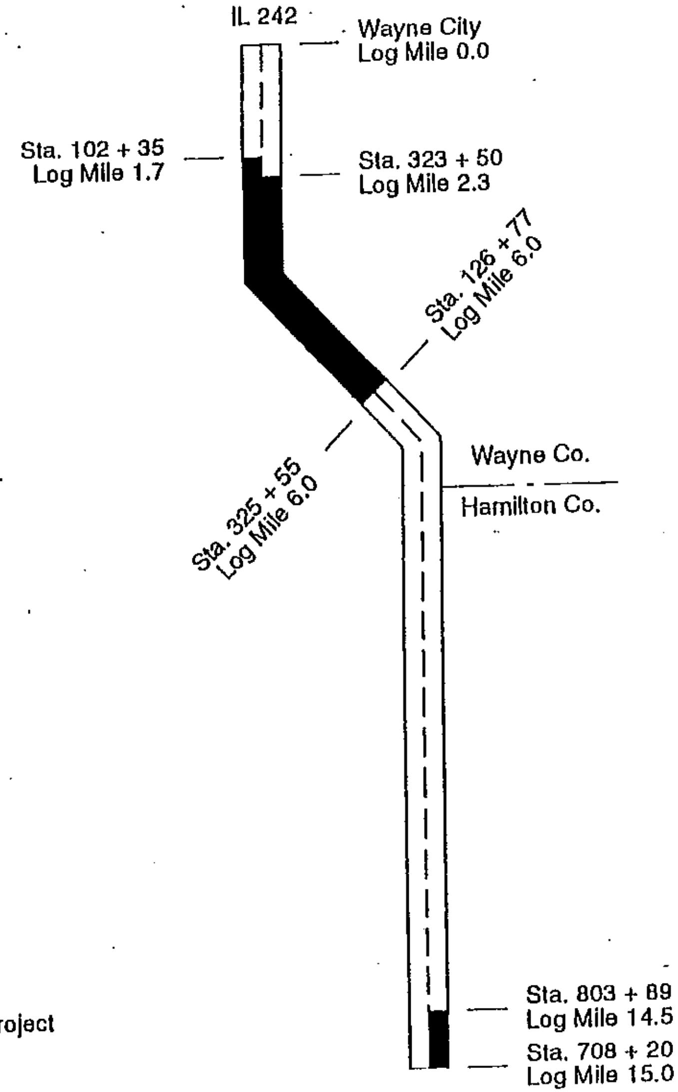
Project B


District 6
To Beardstown
Cass Co.
Morgan Co.
IL 104
IL 104
US 67
IL 100
Project
IL 104
IL 100
Log Mile 0.00
Log Mile 2.20
Log Mile 3.60
N

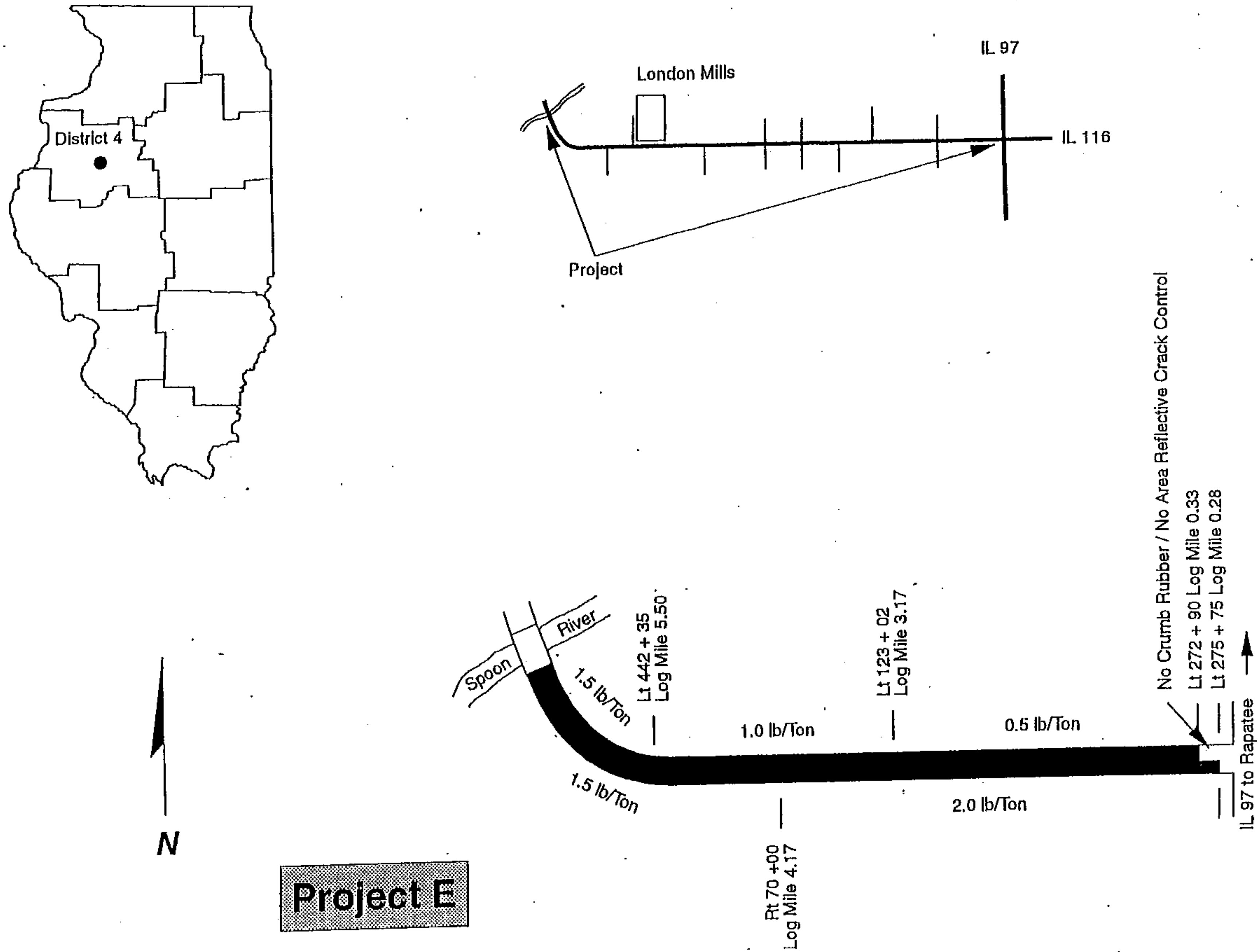
Project C

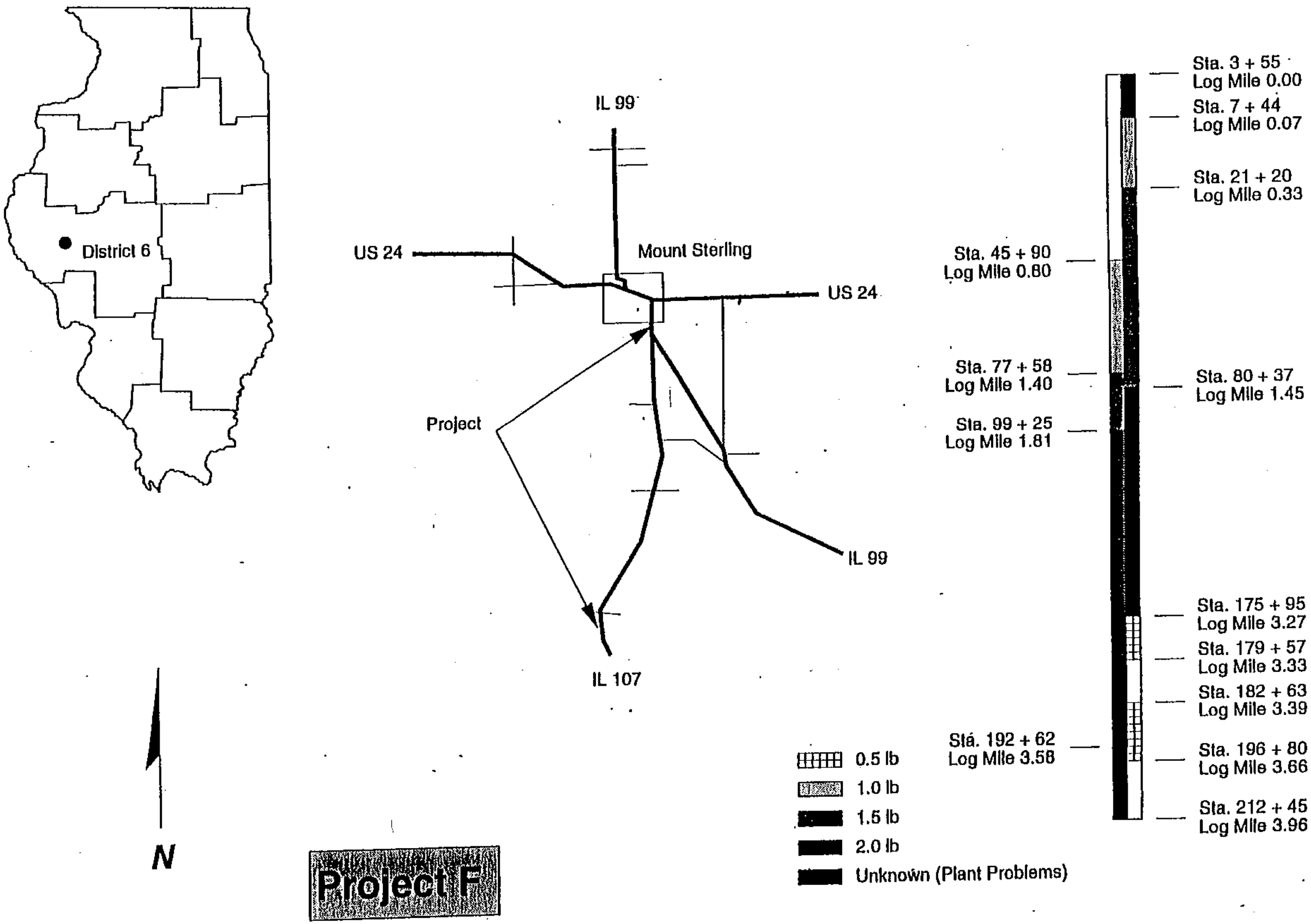

District 7
N


Wayne City
Project
I - 64
Wayne Co.
Hamilton Co.
Belle Prairie City
IL 242
Project
McLeansboro

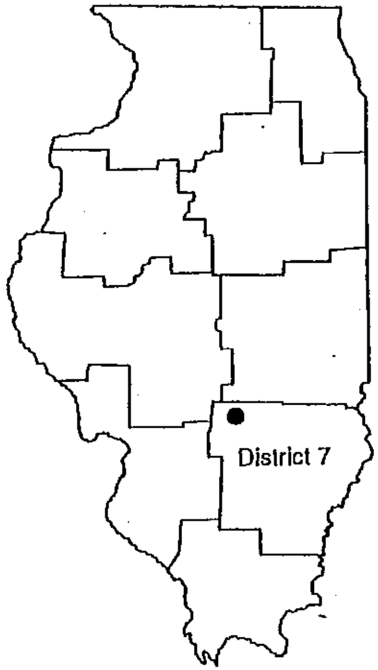

IL 242
Wayne City
Log Mile 0.0
Sta. 102 + 35
Log Mile 1.7
Sta. 323 + 50
Log Mile 2.3
Sta. 126 + 77
Log Mile 6.0
Sta. 325 + 55
Log Mile 6.0
Wayne Co.
Hamilton Co.
Sta. 803 + 89
Log Mile 14.5
Sta. 708 + 20
Log Mile 15.0

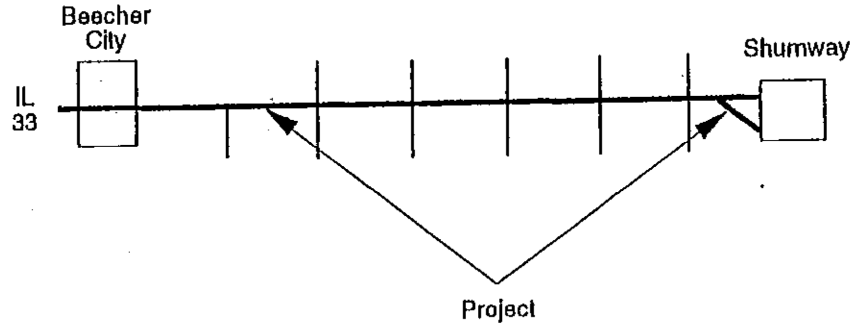
Project D

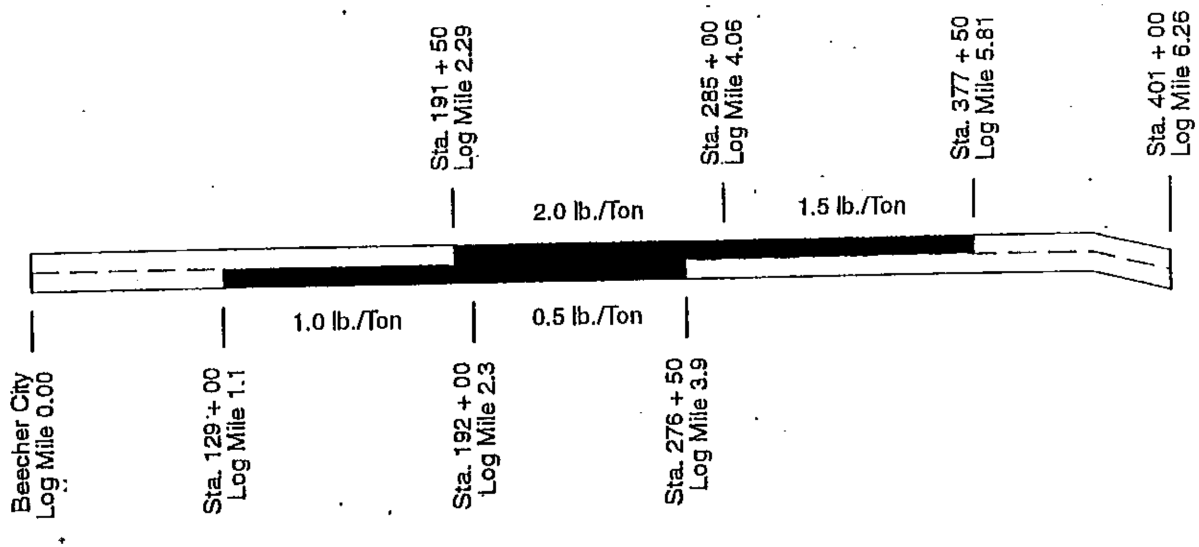

District 4
London Mills
IL 97
IL 116
Project
Spoon
River
1.5 lb/Ton
1.5 lb/Ton
Lt 442 + 35
Log Mile 5.50
1.0 lb/Ton
Lt 123 + 02
Log Mile 3.17
0.5 lb/Ton
2.0 lb/Ton
Rt 70 +00
Log Mile 4.17
No Crumb Rubber / No Area Reflective Crack Control
Lt 272 + 90 Log Mile 0.33
Lt 275 + 75 Log Mile 0.28
IL 97 to Rapatee
N
Project E


District 6
IL 99
US 24
Mount Sterling
US 24
Project
IL 99
IL 107
N
Project F
Sta. 3 + 55
Log Mile 0.00
Sta. 7 + 44
Log Mile 0.07
Sta. 21 + 20
Log Mile 0.33
Sta. 45 + 90
Log Mile 0.80
Sta. 77 + 58
Log Mile 1.40
Sta. 80 + 37
Log Mile 1.45
Sta. 99 + 25
Log Mile 1.81
Sta. 175 + 95
Log Mile 3.27
Sta. 179 + 57
Log Mile 3.33
Sta. 182 + 63
Log Mile 3.39
Sta. 192 + 62
Log Mile 3.58
Sta. 196 + 80
Log Mile 3.66
Sta. 212 + 45
Log Mile 3.96
0.5 lb
1.0 lb
1.5 lb
2.0 lb
Unknown (Plant Problems)

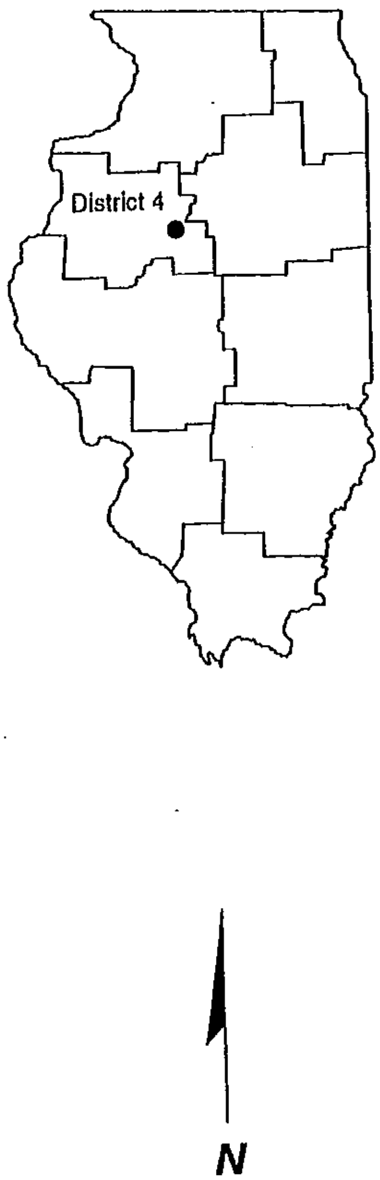
Project G


District 7

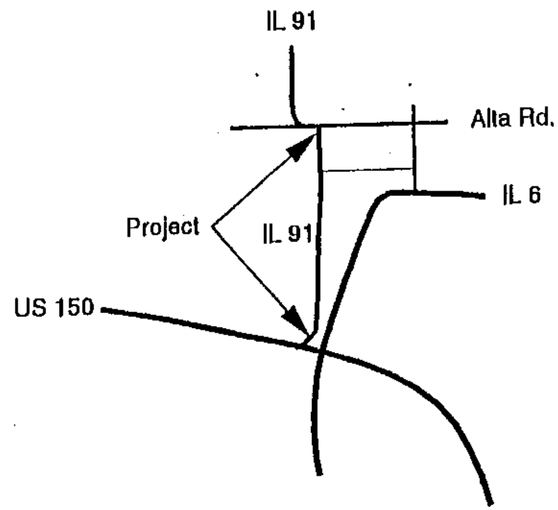

Beecher City
IL 33
Shumway
Project


Sta. 191 + 50
Log Mile 2.29
Sta. 285 + 00
Log Mile 4.06
Sta. 377 + 50
Log Mile 5.81
Sta. 401 + 00
Log Mile 6.26
2.0 lb./Ton
1.5 lb./Ton
1.0 lb./Ton
0.5 lb./Ton
Beecher City
Log Mile 0.00
Sta. 129 + 00
Log Mile 1.1
Sta. 192 + 00
Log Mile 2.3
Sta. 276 + 50
Log Mile 3.9

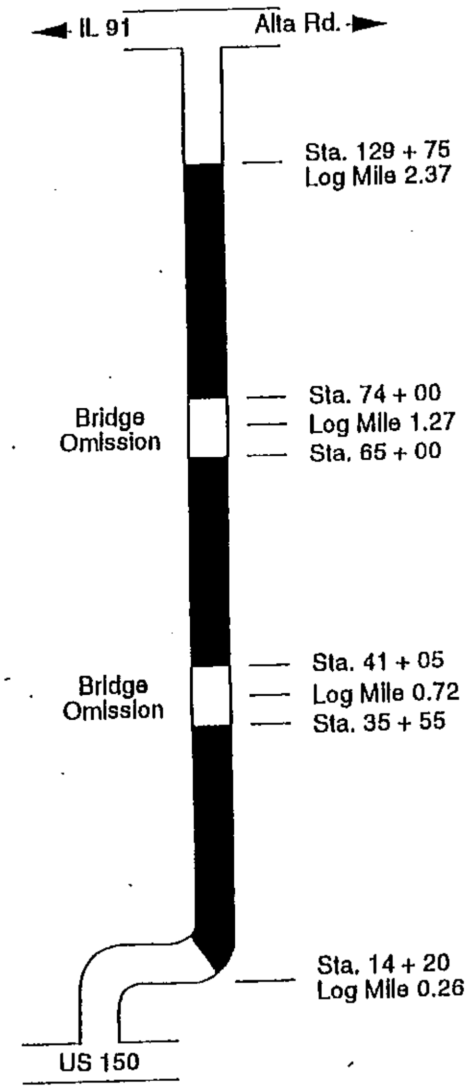
N



District 4
N

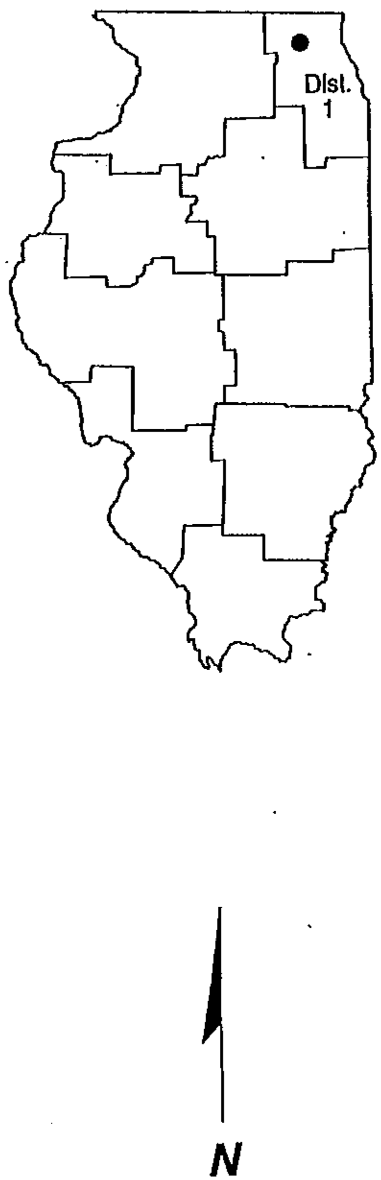


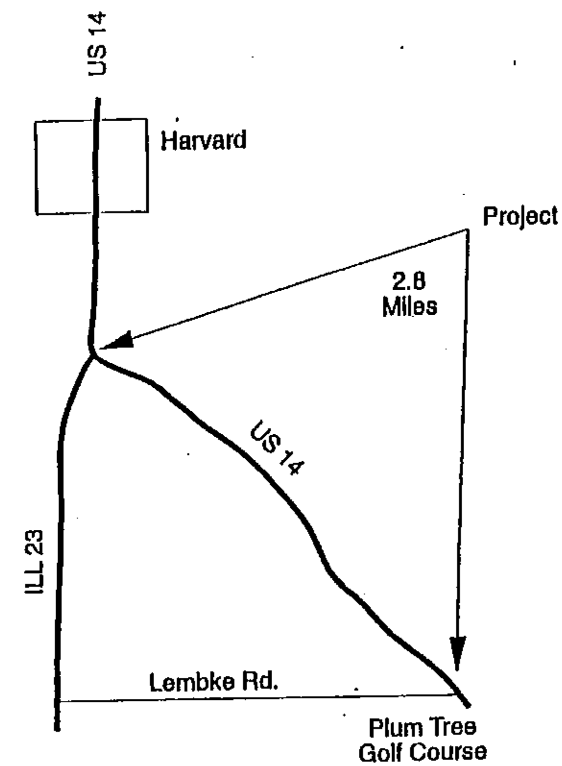
IL 91
Alta Rd.
IL 6
Project
IL 91
US 150

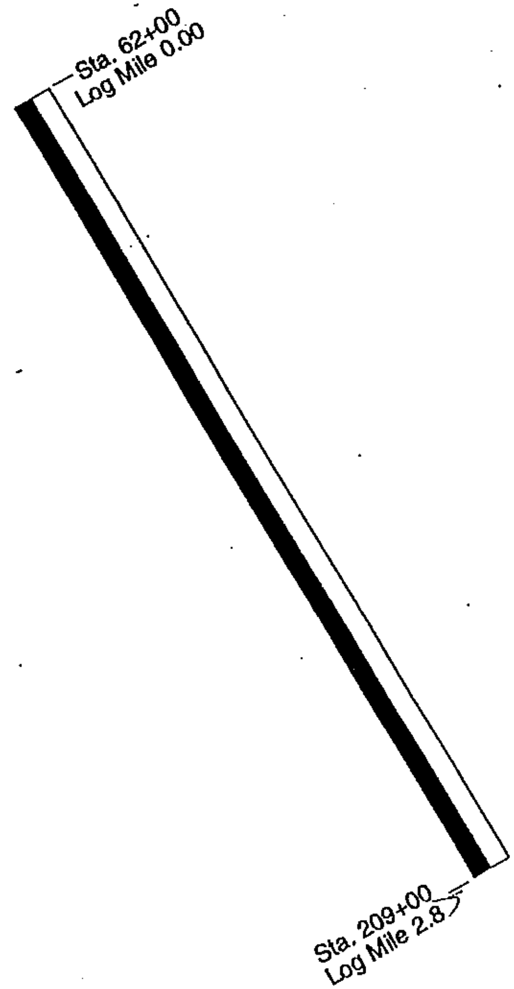


IL 91
Alta Rd.
Sta. 129 + 75
Log Mile 2.37
Bridge
Omission
Sta. 74 + 00
Log Mile 1.27
Sta. 65 + 00
Bridge
Omission
Sta. 41 + 05
Log Mile 0.72
Sta. 35 + 55
Sta. 14 + 20
Log Mile 0.26
US 150

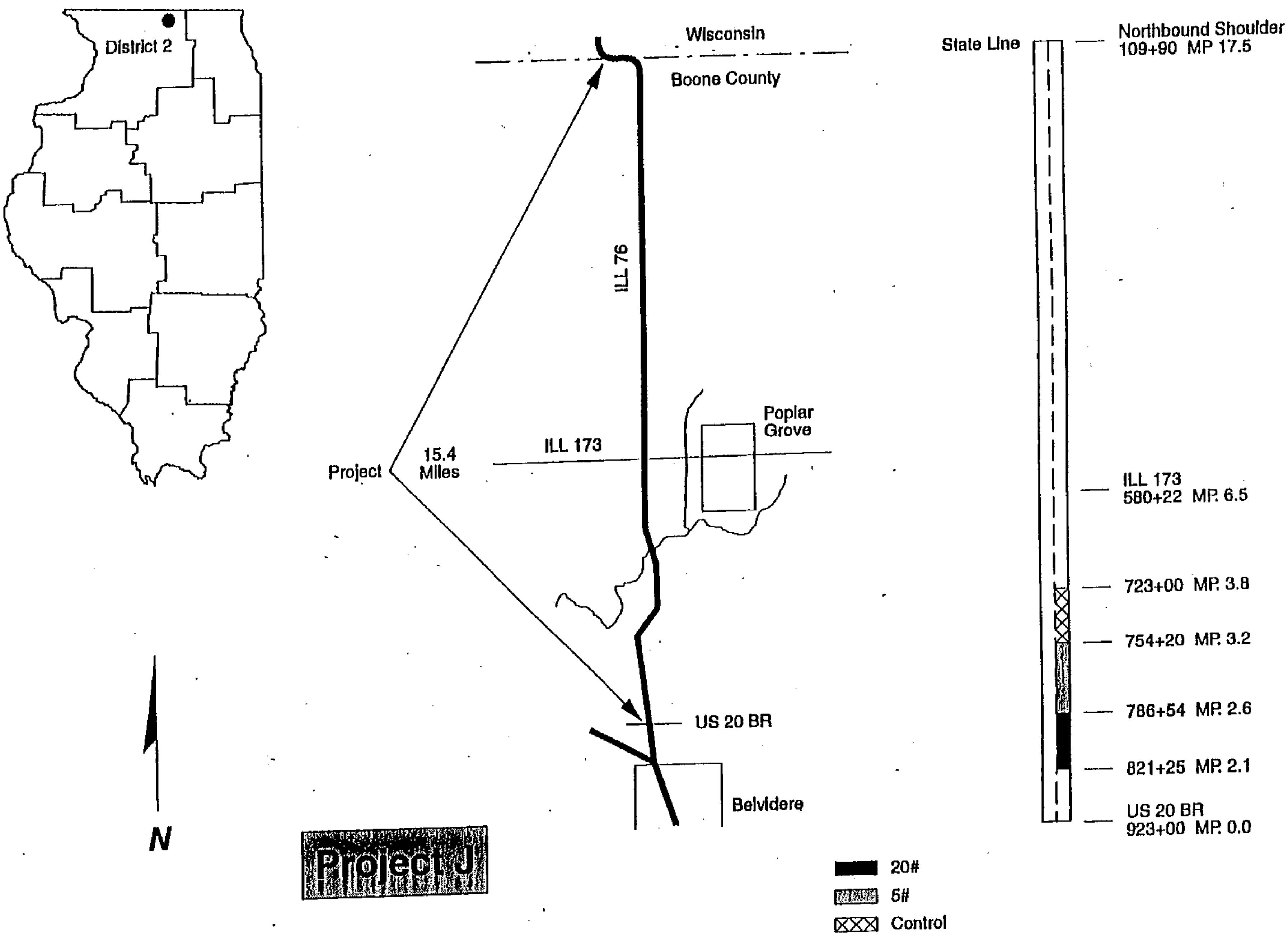
Project H

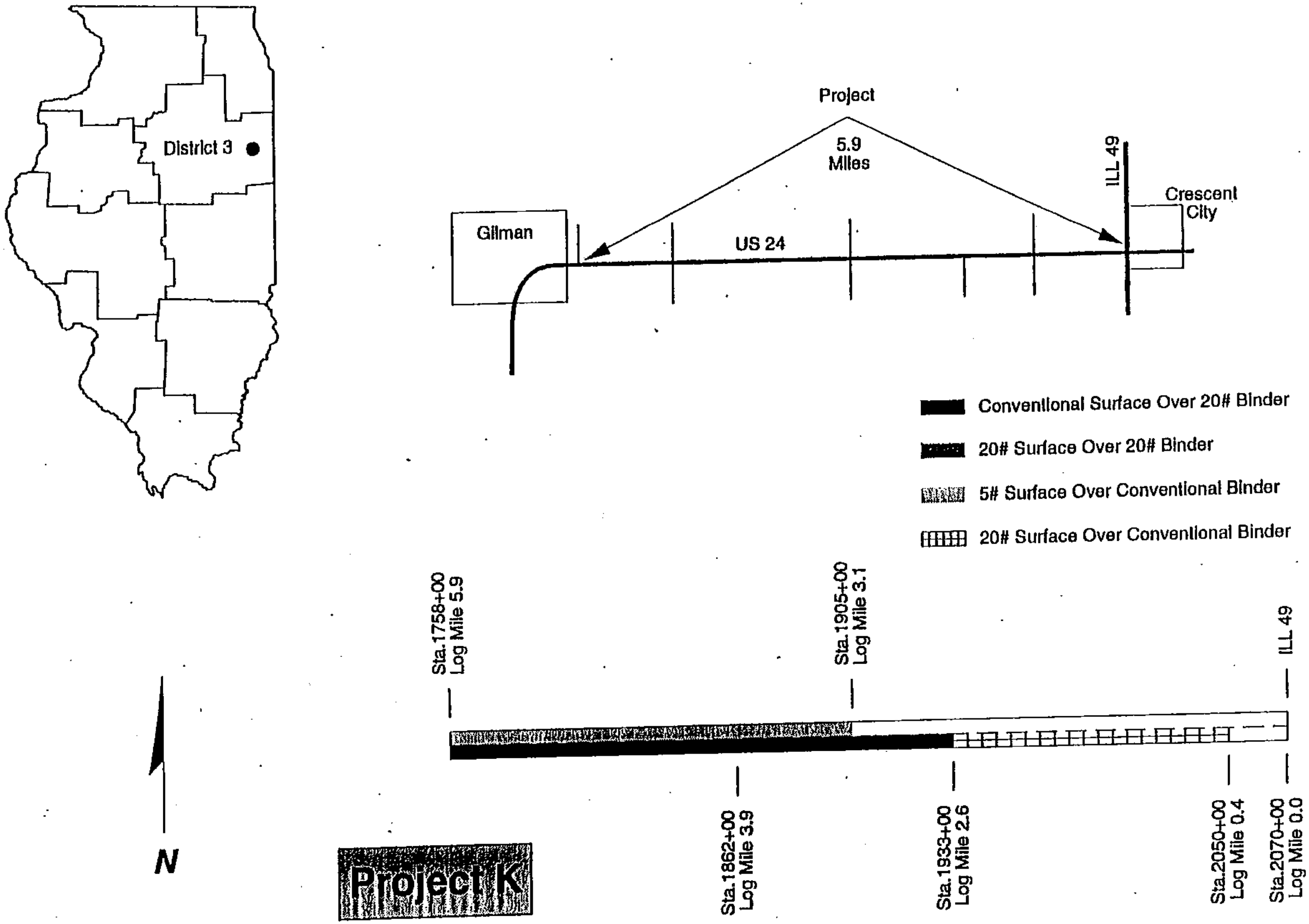

Dist.
1
N


US 14
Harvard
Project
2.8
Miles
US 14
ILL 23
Lembke Rd.
Plum Tree
Golf Course


Sta. 62+00
Log Mile 0.00
Sta. 209+00
Log Mile 2.8

Project I


District 2
Wisconsin
Boone County
ILL 76
Poplar Grove
ILL 173
Project
15.4 Miles
US 20 BR
Belvidere
N
Project J
State Line
Northbound Shoulder
109+90 MP 17.5
ILL 173
580+22 MP. 6.5
723+00 MP. 3.8
754+20 MP. 3.2
786+54 MP. 2.6
821+25 MP. 2.1
US 20 BR
923+00 MP. 0.0
20#
5#
Control


District 3
Project
5.9
Miles
ILL 49
Crescent
City
Gilman
US 24
Conventional Surface Over 20# Binder
20# Surface Over 20# Binder
5# Surface Over Conventional Binder
20# Surface Over Conventional Binder
Sta.1758+00
Log Mile 5.9
Sta.1905+00
Log Mile 3.1
ILL 49
Sta.1862+00
Log Mile 3.9
Sta.1933+00
Log Mile 2.6
Sta.2050+00
Log Mile 0.4
Sta.2070+00
Log Mile 0.0
N
Project K

APPENDIX B

Special Provisions

SPECIAL PROVISION
FOR
RUBBER MODIFIED ASPHALT CONCRETE (RUMAC)
Effective March 23, 1993

Description

This special provision stipulates the requirements for materials, manufacturing and placement of rubber modified asphalt concrete (RUMAC) for Class I, Type 2 surface and binder course mixtures. The applicable portions of Section 406 of the Standard Specifications shall apply except as noted below.

Material Requirements

A. Crumb Rubber. The crumb rubber shall be produced from processing automobile and/or truck tires by ambient grinding methods. Heavy equipment tires, uncured or devulcanized rubber will not be permitted. The crumb rubber shall not exceed 0.2 mm (1/16 inch) in length and contain no free metal particles. The metal content shall be determined by thoroughly passing a magnet through a 50 gram sample. Metal embedded in rubber particles will be permitted. The crumb rubber shall be free of contaminates to the following tolerances:

Fiber content	1.0% by weight, max
Mineral content	0.3% by weight, max
Moisture content	0.75%

Fiber content shall be determined by weighing fiber balls which are formed during the gradation test procedure. Rubber particles shall be removed from the fiber balls before weighing.

The moisture content shall be determined in accordance with AASHTO T-255, using a controlled temperature oven at 60° C (140° F) and 50 gram sample.

The mineral content shall be determined by saline float separation. A 50 gram sample shall be stirred into a 1 liter glass beaker filled with saline solution (1 part table salt into 3 parts distilled water). Allow the sample to stand for 30 minutes. The mineral content is that material which does not float to the top of the beaker.

When tested in accordance with ASTM C-136 a 50 gram sample shall conform to the following gradation requirements:

Sieve Size	Percent Passing
2.36 mm (No. 8)	100
1.18 mm (No. 16)	65±10
600 um (No. 30)	30±10
300 um (No. 50)	10±5

A mineral powder (such as calcium carbonate) meeting AASHTO M17 requirements may be added, up to a maximum of 4% by weight, to reduce sticking and caking of the crumb rubber particles.

Crumb rubber shall have a specific gravity of 1.15 ± 0.05 when tested in accordance with ASTM D-1817 and shall meet the following chemical requirements:

Property	Allowable Percentage	Test Method
Carbon Black	25 - 38	ASTM D-297
Ash Content	8.0 Max.	ASTM D-297
Acetone Extract	10 - 22	ASTM D-297
Natural Rubber	5 - 30	ASTM D-297

The crumb rubber may be provided in bulk or in whole plastic containers. Plastic containers shall be made from low density polyethylene having a melting point less than 115° C (240° F). The manufacturer shall ship along with the ground rubber, certificates of compliance which certify that all requirements of this specification are complied with for each production lot number or shipment.

B. Anti-stripping Agent. If required, an approved, heat stable anti-stripping agent shall be provided in accordance with the Department's Special Provision for "Use of Anti-Stripping for Class I, Type 1 & 2 Mixtures (Binder and Surface)" (eff. 9-1-89).

Composition of the Mixture

Four (4) test sections and a control section shall be constructed as indicated on the plans. The test sections shall contain approximately 1500 tons of mix containing respectively 0.5 lbs, 1.0 lbs, 1.5 lbs, and 2.0 lbs of crumb rubber per ton of mix. The control section shall not contain crumb rubber.

The asphalt content in the established job mix formula shall be increased up to 0.3% for the mixture containing 2.0 lbs. of crumb rubber.

Hot Mix Plant

The type of plant used for the manufacture of RUMAC mixtures may be either a batch or drier drum plant meeting the requirements of 802.01, with the following exceptions:

A. Requirements for Batch Plants. The amount of ground rubber shall accurately be determined by weighing or metering to the approval of the Engineer. The method shall feed the material uniformly.

B. Requirements for Drier Drum Plants. Ground rubber introduced into the mixer shall be drawn from storage bins by a continuous mechanical feeder which will uniformly feed the mixer within plus or minus 0.50% of the required amount. Positive interlocking control between the flow of the ground rubber and aggregates shall be provided.

The crumb rubber shall not enter the drum with the cold aggregate. It shall be introduced to the drum beyond the flame but before the asphalt cement discharge.

C. Plant Modification. Introduction of crumb rubber into RUMAC mixtures may require plant modification. The Engineer will have final approval of the plant.

Compaction of RUMAC Mixtures

During laydown, the Engineer will peridoically determine the mat density in accordance with the Department's test procedure Il 2950-92, "Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method." Final acceptance of mat density shall be based on cores (other than those obtained for core-nuclear correlation) obtained by the contractor at locations specified by the Engineer. Core densities will be determined by the Engineer in accordance with Departmental procedures.

"FIXED RATE"

SPECIAL PROVISION
FOR
RUBBER MODIFIED ASPHALT CONCRETE (RUMAC)

Effective March 1, 1993
Revised April 15, 1993

Description

This special provision stipulates the requirements for materials, manufacturing and placement of rubber modified asphalt concrete (RUMAC) for Class I, Type 2 surface and binder course mixtures. The applicable portions of Section 406 of the Standard Specifications shall apply except as noted below.

Material Requirements

A. Crumb Rubber. The crumb rubber shall be produced form processing automobile and/or truck tires by ambient grinding methods. Heavy equipment tires, uncured or devulcanized rubber will not be permitted. The crumb rubber shall not exceed 0.2 mm (1/16 inch) in length and contain no free metal particles. The metal content shall be determined by thoroughly passing a magnet through a 50 gram sample. Metal embedded in rubber particles will be permitted. The crumb rubber shall be free of contaminates to the following tolerances:

Fiber content	0.2% by weight, max
Mineral content	0.3% by weight, max
Moisture content	0.75%

Fiber content shall be determined by weighing fiber balls which are formed during the gradation test procedure. Rubber particles shall be removed from the fiber balls before weighing.

The moisture content shall be determined in accordance with AASHTO T-255, using a controlled temperature oven at 60° C (140° F) and 50 gram sample.

The mineral content shall be determined by saline float separation. A 50 gram sample shall be stirred into a 1 liter glass beaker filled with saline solution (1 part table salt into 3 parts distilled water). Allow the sample to stand for 30 minutes. The mineral content is that material which does not float to the top of the beaker.

When tested in accordance with ASTM C-136 a 50 gram sample shall conform to the following gradation requirements:

Sieve Size	Percent Passing
2.36 mm (No. 8)	100
1.18 mm (No. 16)	65+10
600 um (No. 30)	30±10
300 um (No. 50)	10±5

A mineral powder (such as calcium carbonate) meeting AASHTO M17 requirements may be added, up to a maximum of 4% by weight, to reduce sticking and caking of the crumb rubber particles.

Crumb rubber shall have a specific gravity of 1.15 $\pm$ 0.05 when tested in accordance with ASTM D-1817 and shall meet the following chemical requirements:

Property	Allowable Percentage	Test Method
Carbon Black	25 - 38	ASTM D-297
Ash Content	8.0 Max.	ASTM D-297
Acetone Extract	10 - 18	ASTM D-297
Natural Rubber	15 - 30	ASTM D-297

The crumb rubber may be provided in bulk or in whole plastic containers. Plastic containers shall be made from low density polyethylene having a melting point less than 115° C (240° F). The manufacturer shall ship along with the ground rubber, certificates of compliance which certify that all requirements of this specification are complied with for each production lot number or shipment.

B. Reclaimed Asphalt Pavement (RAP). RAP will not be permitted in the mixture.

C. Anti-stripping Agent. If required, an approved, heat stable anti-stripping agent shall be provided in accordance with the Department's Special Provision for "Use of Anti-Stripping for Class I, Type 1 & 2 Mixtures (Binder and Surface)" (eff. 9-1-89).

Composition of the Mixture

After a representative quantity of aggregate has been produced and not less than thirty (30) calendar days before production of the RUMAC mix begins, the Contractor shall furnish the Department representative samples of the materials to be used in the mixture for the project as follows:

Material	Amount
Aggregate	115 Kg. (250 lbs.) of each stockpile
Crumb Rubber	30 Kg. (60 lbs.)
Mineral Filler	10 Kg. (20 lbs.)
Asphalt Cement	7.5 L. (2 gals.) in one liter (quart) containers
Liquid Anti-Strip Additive	.5 L. (1 pint)
or	
Hydrated Lime	10 Kg. (20 lbs.)

The thirty (30) calendar day period will begin when samples of all materials, complying with the specifications, have been received by the Engineer or the material laboratory as directed by the Engineer. The Department will provide one mix design for each class of mix specified, at no cost to the Contractor. The cost of the development of any additional mix designs requested by the Contractor shall be borne by the Contractor.

The crumb rubber content shall not exceed one and a half percent by weight (1.5%) of total mix. The optimum rubber content will be determined by the mix design.

Hot Mix Plant

The type of plant used for the manufacture of RUMAC mixtures may be either a batch or drier drum plant meeting the requirements of 802.01, with the following exceptions:

A. Requirements for Batch Plants. The amount of ground rubber shall be determined by weighing on approved scales or load cells. The method shall feed the material uniformly into the pugmill mixer within plus or minus 0.50% of the amount required. The aggregates and ground rubber shall be combined and mixed throughly for a minimum of 25 seconds prior to introducing the asphalt cement. The wet mixing time shall be not less than 35 seconds.

B. Requirements for Drier Drum Plants. Ground rubber introduced into the mixer shall be drawn from storage bins by a continuous mechanical feeder which will uniformly feed the mixer with plus or minus 0.50% of the required amount. Satisfactory means shall be provided to have a positive interlocking control between the flow of the ground rubber and aggregates.

   The crumb rubber shall not enter the drum with the cold aggregate. It shall be introduced to the drum beyond the flame but before the asphalt cement discharge. The crumb rubber shall be mixed with the dry hot aggregate for at least one drum revolution before the asphalt cement is introduced.

C. Plant Modification. Introduction of crumb rubber into RUMAC mixtures may require plant modification. The Engineer will have final approval of the plant.

D. Storage and Conveyance. Heated silo storage of RUMAC mixtures shall not exceed 1 hour. Conveyance of the hot mixture on rubber belts will not be permitted.

Preliminary Test Strip/Start-Up

A preliminary test strip and start-up for the RUMAC mixture shall be conducted in accordance with the Department's "Guidelines for Preliminary Test Strip and Start-Up for Stone Matrix Asphalt/Crumb Rubber Asphalt Mixtures." Note: Preliminary Test Strip is different than the normal test strip required by the Department.

Placement of RUMAC Mixtures.

The RUMAC mixtures shall be delivered at a temperature of 150° C (300°F) to 175° C (350° F).

Compaction of RUMAC Mixtures.

Pneumatic - tired rollers will not be permitted.

During laydown, the Engineer will periodically determine the mat density in accordance with the Department's test procedure Il 2950-92, "Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method." Final acceptance of mat density shall be based on cores obtained by the contractor at locations specified by the Engineer. Core densities will be determined by the Engineer in accordance with Departmental procedures.

Opening to Traffic

Traffic shall not be permitted on the new surface until the temperature of the mat has dropped below 60° C (140° F).

Method of Measurement

RUMAC mixtures shall be measured in accordance with Article 406.22.

Basis of Payment

This work will be paid for in accordance with Article 406.23 at the contract unit price per ton for RUBBER MODIFIED ASPHALT CONCRETE, measured as specified herein, and at the contract unit price each for PRELIMINARY TEST STRIP (RUMAC). The cost of the modified start-up shall be included in the unit price per ton for RUBBER MODIFIED ASPHALT CONCRETE.

SPECIAL PROVISION FOR BITUMINOUS CONCRETE BINDER AND SURFACE COURSES MIXTURES B AND D, CLASS I, TYPE 2, RUBBER MODIFIED ASPHALT (RUMAC) 1.0% AND 0.25%

Effective March 1, 1993
Revised March 3, 1995

Description

This special provision stipulates the requirements for materials, manufacturing and placement of BITUMINOUS CONCRETE BINDER AND SURFACE COURSES, MIXTURES B AND D, CLASS I, TYPE 2 RUBBER MODIFIED ASPHALT (RUMAC) 1.0% and 0.25% The applicable portions of Section 406 of the Standard Specifications shall apply except as noted below. The QC/QA specifications for HMA do not apply to the asphalt concrete described herein.

Material Requirements

A. Crumb Rubber. The crumb rubber shall be produced from processing automobile and/or truck tires by ambient grinding methods. Heavy equipment tires, uncured or devulcanized rubber will not be permitted. The crumb rubber shall not exceed 2 mm (1/16 inch) in length and contain no free metal particles. The metal content shall be determined by thoroughly passing a magnet through a 100 gram sample. Metal embedded in rubber particles will be permitted. The crumb rubber shall be free of contaminates to the following tolerances:

Fiber Content0.2% by weight, max.

Mineral Content0.3% by weight, max.

Moisture Content0.75%

Fiber content shall be determined by weighing fiber balls which are formed during the gradation test procedure. Rubber particles shall be removed from the fiber balls before weighing.

The moisture content shall be determined in accordance with AASHTO T-255, using a controlled temperature oven at 60°C (140° F) and 100 gram sample.

The mineral content shall be determined by saline float separation. A 100 gram sample shall be stirred into a one liter glass beaker filled with saline solution (one part table salt into three parts distilled water). Allow the sample to stand for 30 minutes. The mineral content is that material which does not float to the top of the beaker.

When tested in accordance with ASTM C-136 a 100 gram sample shall conform to the following gradation requirements:

Sieve Size	Percent Passing
2.36 mm (No. 8)	100
1.18 mm (No. 16)	70 ± 10
600 um (No. 30)	35 ± 10
300 um (No. 50)	10 Min.

A mineral powder (such as calcium carbonate) meeting AASHTO M17 requirements may be added, up to a maximum of 5% by weight, to reduce sticking and caking of the crumb rubber particles.

Crumb rubber shall have a specific gravity of 1.15 ± 0.05 when tested in accordance with ASTM D-1817 and shall meet the following chemical requirements:

Property	Allowable Percentage	Test Method
Carbon Black	35 Max.	ASTM D-297
Ash Content	6.0 Max.	ASTM D-297
Acetone Extract	16 Max.	ASTM D-297
Natural Rubber	25 Min.	ASTM D-297

The crumb rubber shall be provided in bulk. The manufacturer shall ship along with the ground rubber, certificates of compliance which certify that all requirements of this specification are complied with for each production lot number or shipment.

B. Reclaimed Asphalt Pavement (RAP). RAP will not be permitted in the mixture.

C. Anti-stripping Agent. If required, an approved, heat stable anti-stripping agent shall be provided in accordance with the Department's Special Provision for "Use of Anti-Stripping for Class I, Type 1 & 2 Mixtures (Binder and Surface)" (Eff. 9-1-89).

Composition of the RUMAC Mixtures

After a representative quantity of aggregate has been produced and not less than 30 calendar days before production of the RUMAC mixes begin, the Contractor shall furnish the Department representative samples of the materials to be used in the mixture for the project as follows:

Material	Amount
Aggregate	115 Kg. (250 pounds) of each stockpile
Crumb Rubber	30 Kg. (60 pounds)
Mineral Filler	10 Kg. (20 pounds)
Asphalt Cement	7.5 L. (2 gallons) in one liter (quart) containers
Liquid Anti-Strip Additive	.5 L. (1 pint)
or	
Hydrated Lime	10 Kg. (20 pounds)

The 3" calendar day period will begin when samples of all materials, complying with the specifications, have been received by the Engineer or the material laboratory as directed by the Engineer. The Department will provide one mix design for each class of mix specified, at no cost to the Contractor. The cost of the development of any additional mix designs requested by the Contractor shall be borne by the Contractor.

For the RUMAC 1.0% mixes, the crumb rubber content shall not exceed one and a half percent by weight (1.5%) of total mix. The optimum rubber content will be determined by the mix design.

AC 20 will be required in all mixes.

Hot Mix Plant

The type of plant used for the manufacture of RUMAC mixtures shall be a drier drum plant (parallel flow or counter flow) meeting the requirements of 802.01, with the following exceptions:

A. Ground rubber introduced into the mixer shall be drawn from storage bins by a continuous mechanical feeder which will uniformly feed the mixer within plus or minus 5.0% of the required amount. Satisfactory means shall be provided to have a positive interlocking control between the flow of the ground rubber and aggregates.

The crumb rubber shall not enter the drum with the cold aggregate.

B. Plant Modification. Introduction of crumb rubber into RUMAC mixtures may require plant modification. The Engineer will have final approval of the plant.

C. Storage and Conveyance. Heated silo storage of RUMAC mixtures shall not exceed one hour. Conveyance of the hot mixtures on rubber belts will not be permitted.

D. Hauling Equipment. The equipment used shall conform to Section 801 of the Standard Specifications for Road and Bridge Construction and the following requirements:

All trucks shall be tarped when hauling the RUMAC mixtures to the paver. Only release agents listed on the Department's acceptable list shall be used. The use of sand or diesel fuel shall not be permitted. A laborer may be required to ensure that all truck beds are clean, prior to being loaded.

Test Strip--RUMAC 1.0% Mixtures ONLY

A test strip (250 metric tons, 300 tons) for each of the RUMAC 1.0% mixtures shall be conducted in accordance with Article 406.15(b) of the Standard Specifications.

NOTE: Production of RUMAC 1.0% mixtures will not be allowed to resume until all laboratory tests are completed from the test strip.

Placement of RUMAC Mixtures

1,800 metric tons (2,000 tons) of each RUMAC mixture shall be placed. The RUMAC mixtures shall be placed in such a manner that four test sections exist:

RUMAC 1.0% surface over RUMAC 1.0% binder;
Conventional surface over RUMAC 1.0% binder;
RUMAC 1.0% surface over conventional level binder;
RUMAC 0.25% surface over conventional level binder.

The tonnages placed in the test strip areas will be in addition to the above mentioned mainline quantities.

The RUMAC mixtures shall be delivered at a temperature of 150° C (300° F) to 175° C (350° F).

Compaction of RUMAC Mixtures

The rollers required for compaction of the RUMAC mixtures shall be two breakdown vibratory rollers and one finish steel-wheeled roller.

Pneumatic-tired rollers will not be permitted.

Compaction shall continue until the required density range has been achieved. The required density range shall be 93% to 96% of the theoretical maximum density. Care shall be taken to avoid excessive aggregate breakage.

During laydown, the Engineer will periodically determine the mat density in accordance with the Departments' test procedure Il 2950-92, "Standard Test Method for Determination of Density of Bituminous Concrete In-Place by Nuclear Method." Final acceptance of mat density shall be based on cores obtained by the contractor at locations specified by the Engineer. Core densities will be determined by the Engineer in accordance with Departmental procedures.

Opening to Traffic

Traffic shall not be permitted on the new surface until the temperature of the mat has dropped below 60°C (140°F).

Basis of Payment

This work will be paid for at the contract unit price per metric ton (ton) for:

BITUMINOUS CONCRETE BINDER COURSE, MIXTURE B, CLASS I, TYPE 2
RUBBER MODIFIED ASPHALT (RUMAC) 1.0%;
BITUMINOUS CONCRETE SURFACE COURSE, MIXTURE D, CLASS I,
TYPE 2, RUBBER MODIFIED ASPHALT (RUMAC) 1.0%; and
BITUMINOUS CONCRETE SURFACE COURSE, MIXTURE D, CLASS I,
TYPE 2, RUBBER MODIFIED ASPHALT (RUMAC) 0.25%
The test strips for each of the RUMAC 1.0% mixes will be paid for at the contract unit price each for CONSTRUCTING TEST STRIP (RUMAC).

RUBBER MODIFIED ASPHALT CONCRETE (RUMAC): The Contractor shall schedule his operations so as to complete the placement of all bituminous materials containing RUMAC by October 1, 1995. The contractor shall note that this time limit is based on an expedited work schedule.

Should the contractor fail to complete the work by the specified time, the contractor shall be liable to the Departmet in the amount specified in the table in Article 108.09 of the Standard Specifications, not as a penalty, but as liquidated and ascertained damages for each calendar day after October 1, 1995. Such damages may be deducted by the Department from any monies due the contractor.

In fixing the damages as set out herein, the desire is to establish a certain mode of calculation for the work since the Department's actual loss, in the event of delay, cannot be predetermined, would be difficult of ascertainment, and a matter of argument and unprofitable litigation. This said mode is an equitable rule for measurement of the Department's actual loss and fairly takes into account the loss of use of the roadway if the project is delayed in completion. The Department shall not be required to provide any actual loss in order to recover these liquidated damages provided herein, as said damages are very difficult to ascertain. Furthermore, no provision of this clause shall be construed as a penalty, as such is not the intention of the parties.

A calendar day is every day on the calendar and starts at 12:00 midnight and ends at the following 12:00 midnight, twenty-four hours later. No payment will be paid for any day less than twenty-four hours.

State of Illinois
Department of Transportation

SPECIAL PROVISION
FOR
COARSE AGGREGATE FOR CLASS I BITUMINOUS MIXTURE

Effective June 30, 1994
Revised November 1, 1994

This Special Provision modifies the requirements for Coarse Aggregates contained in Bituminous Concrete Leveling Binder, Binder, and Surface Course Class I as specified in Sections 406 and 704 of the Standard Specifications as follows:

> The percent passing the 1.18 mm (No. 16) sieve for gradations CA 8, CA 11, CA 13 or CA 16 as set forth in the gradation table in Article 704.01(c) shall be 4 ± 4%.

7326I

APPENDIX C

Job Mix Formulas

Table C-1. Rubberized Asphalt Pavements
Job Mix Formulas

	Project A 'Bitconc SCS 2 Rec C'	Project B 'Bitconc SCS 2 D'	Project C 'Bitconc SCS 2 Rub C'	Project D 'Bitconc SCS 2 Rub C'
1	100	100	100	100
3/4	100	100	100	100
1/2	99	97	100	98
3/8	90	82	98	89
#4	55	53	58	47
#8	36	36	33	31
#16	27	27	24	24
#30	19	18	17	17
#50	10	9	10	10
#100	6	6	7	8
#200	4.4	4.6	5.8	5.0
AC	4.8	5.3	6.4	5.5

Table C-1. Rubberized Asphalt Pavements
Job Mix Formulas Continued

	Project D 'Bitconc SCS 2 Rub D'	Project E 'Bitconc SCS 2 Rub D'	Project F 'Bitconc SCS 2 C'	Project G 'Bitconc SCS 2 Rec C'
1	100	100	100	100
3/4	100	100	100	100
1/2	98	100	99	100
3/8	89	99	85	98
#4	47	60	56	54
#8	31	40	39	33
#16	24	29	29	24
#30	17	22	20	16
#50	10	10	8	8
#100	8	6	6	6
#200	5.0	5.0	4.5	5.0
AC	5.8	5.8	4.9	5.7

Table C-1. Rubberized Asphalt Pavements
Job Mix Formulas Continued

	Project H 'Bitconc SCS 2 Rub D'	Project I 'Bitconc SCS 2 Rub D'	Project J 'Bitconc BCS 2 Rec B'	Project J 'Bitconc Base CSE Rec Mix'
1	100	100	100	95
3/4	100	100	98	98
1/2	100	100	74	75
3/8	99	98	61	61
#4	55	50	37	43
#8	36	32	28	28
#16	27	26	24	24
#30	19	19	19	19
#50	8	10	10	10
#100	5	6	6	6
#200	3.8	5.0	4.1	8.0
AC	6.3	5.6	4.2	4.2

Table C-1. Rubberized Asphalt Pavements Job Mix Formulas Continued

	Project K 'Bitconc BCS 2 Rub B'	Project K 'Bitconc SCS 2 Rub D'
1	100	100
3/4	96	100
1/2	76	100
3/8	63	98
#4	36	51
#8	26	33
#16	23	29
#30	18	23
#50	9	12
#100	5	6
#200	4.0	5.0
AC	4.7	5.4

APPENDIX D

Definitions of Distresses

ALLIGATOR OR FATIGUE CRACKING

Description:

Alligator or fatigue cracking is a series of interconnecting cracks forming many-sided, sharp-edged pieces. The cracks develop a pattern resembling chicken wire or the skin of an alligator. The longest side of the pieces is usually less than one-foot in length. Fatigue or alligator cracking is a load associated distress. Pattern-type cracking occurring over an area not subjected to traffic load is rated as "Block Cracking".

Severity Levels:

L - Longitudinal disconnected hairline cracks running parallel to each other. The cracks are not spalled. Initially there may only be a single crack in the wheel path. Defined as Class 1 cracking at AASHO Road Test.

M - Further development of low severity fatigue cracking into a pattern of pieces formed by cracks that may be sealed. Defined as Class 2 cracking at AASHO Road Test.

H - Medium fatigue cracking has progressed so that pieces are more severely spalled at the edges and loosened until the cells rock under traffic. Pumping may exist. Defined as Class 3 cracking at AASHO Road Test.

How to Record:

Alligator and fatigue cracking is measured as the length of pavement (lane feet) where the distress occurs anywhere within the lane. The highest severity level present within the width of the pavement should be recorded.

ASPHALT BLEEDING

Description:

Asphalt bleeding is the presence of excess asphalt material on the pavement surface. It usually occurs in the wheelpaths. Asphalt material spilled onto the surface from sealing operations or moving vehicles should not be included.

Severity Levels:

No degrees of severity are defined.

How to Record:

Asphalt bleeding is recorded as the length of pavement (lane feet) where the distress occurs anywhere within the lane.

BLOCK CRACKING

Description:

Block cracking, sometimes called area cracking, divides the asphalt surface into approximately rectangular pieces. These blocks range in size from approximately 1-ft^2. to 100 ft^2. Cracking into larger blocks is generally rated as longitudinal and/or transverse cracking. Block cracking normally occurs over a large portion of the pavement area. The cracks usually extend only a short distance into the bituminous surface. Block cracking should not be mistaken for Fatigue Cracking or "Alligator Cracking", which forms smaller, many-sided pieces having sharp angles.

Severity Levels:

L - Cracks are tight (mean width less than or equal to 1/4") with minor or no spalling present.

M - Crack width is between 1/4" and 1/2". Cracks may be moderately spalled. Low severity random parallel cracking may exist near the crack or at the intersection of cracks.

H - One or more of the following conditions exist: (1) crack width is greater than 1/2", (2) crack is severely spalled, (3) medium or severe random parallel cracking exists near the crack or at the intersection of the cracks, (4) major sealing or other major maintenance activity has been performed.

How to Record:

Block cracking is measured as the length of pavement (lane feet) where the distress occurs anywhere within the lane. If a length of pavement exhibits more than one severity level, it should be subdivided into lengths exhibiting one predominate severity level.

Note:

Most sealed cracks are of high severity because of original crack width and/or severe spalling. In some cases, low and medium severity cracks have been sealed for preventive maintenance.

CENTER OF LANE CRACKING

Description:

Center of lane cracking is a longitudinal crack situated in the center of a lane. This crack is very straight in nature and does not wander or meander. All other longitudinal cracks should be identified as "Longitudinal Cracking".

Severity Levels:

L - Cracks are tight (mean width less than or equal to 1/4") with minor or no spalling present.

M - Crack width is between 1/4" and 1/2". Cracks may be moderately spalled. Low severity random parallel cracking may exist near the crack or at the intersection of cracks.

H - One or more of the following conditions exist: (1) crack width is greater than 1/2", (2) crack is severely spalled, (3) medium or severe random parallel cracking exists near the crack or at the intersection of cracks, (4) major sealing or other major maintenance activity has been performed.

How to Record:

Center of lane cracking is measured in lineal feet. The length and severity level of each crack should he identified and recorded. If the crack does not have the same severity level along its entire length, each general portion should be recorded separately.

Note:

Most sealed cracks are of high severity because of original crack width and/or severe spalling. In some cases, low and medium severity cracks have been sealed for preventive maintenance.

CENTERLINE CRACKING

Description:

Centerline cracking is located alone the centerline of two-lane pavements and between lanes of pavements with three or more lanes. The joint formed by the bituminous paving operation is included in this distress. The reflection crack caused by the centerline joint in the underlying Portland cement concrete (PCC) is also included.

Severity Levels:

L - Cracks are tight (mean width less than or equal to 1/4") with minor or no spalling present.

M - Crack width is between 1/4" and 1/2". Cracks may be moderately spalled. Low severity random parallel cracking may exist near the crack or at the intersection of cracks.

H - One or more of the following conditions exist: (1) crack width is greater than 1/2", (2) crack is severely spalled, (3) medium or severe random parallel cracking exists near the crack or at the intersection of cracks, (4) major sealing or other major maintenance activity has been performed.

How to Record:

The total lengths, in feet, of each severity level existing in the sample unit are recorded.

Note:

Most sealed cracks are of high severity because of original crack width and/or severe spalling. In some cases, low and medium severity cracks have been sealed for preventive maintenance.

LONGITUDINAL CRACKING

Description:

Longitudinal cracks are parallel to the pavement's centerline. They can appear anywhere between the centerline and the outer edge of the outer wheelpath. This crack may be fairly straight or may meander within a lane width. Very straight cracks located in the exact center of the lane are not included as these are identified as "Center of Lane Cracking".

Severity Levels:

L - Cracks are tight (mean width less than or equal to 1/4") with minor or no spalling present.

M - Crack width is between 1/4" and 1/2". Cracks may be moderately spalled. Low severity random parallel cracking may exist near the crack or at the intersection of cracks.

H - One or more of the following conditions exist: (1) crack width is greater than 1/2", (2) crack is severely spalled, (3) medium or severe random parallel cracking exists near the crack or at the intersection of cracks, (4) major sealing or other major maintenance activity has been performed.

How to Record:

Longitudinal cracking is measured in lineal feet. The length and severity level of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each general portion should be recorded separately.

Note:

Most sealed cracks are of high severity because of original crack width and/or severe spalling. In some cases, low and medium severity cracks have been sealed for preventive maintenance.

OVERLAID PATCH DETERIORATION

Description:

Overlaid patch deterioration occurs when a patch in the underlying pavement has reflected through the bituminous overlay. Only the area between the reflected cracks is to be evaluated.

Severity Levels:

L - Cracks are tight and the bituminous overlay is in very good condition in the vicinity of the cracks.

M - The bituminous overlay is somewhat deteriorated, having medium level of severity for any type of distress described in this manual.

H - The bituminous overlay is badly deteriorated in the area of the patch and in need of maintenance.

How to Record:

Each reflected patch is measured in square feet of surface and is rated to the highest level of distress present. The reflected cracks are rated and recorded separately as "Reflected Patch Cracking". Only those patches whose edges have reflected through the overlay enough to determine the area should be rated. For jointed pavements, both cracks should extend at least halfway across a lane.

POTHOLES AND LOCALIZED DISTRESS

Description:

Potholes and localized distress are bowl-shaped holes of various sizes in the pavement surface. The bituminous material has broken into small pieces by fatigue cracking or by localized disintegration of the mixture and the material is removed by traffic.

Severity Levels:

Area (ft2)	Less than 1	1-3	Greater than 3
Depth (in)			
Less than 1	L	L	M
1-2	M	M	H
Greater than 2	M	H	H

Potholes that have been filled or partially filled by maintenance forces should be rated the same as an unfilled pothole, i.e., a filled pothole (2 ft^2) with a remaining depth of 1.5" would be rated "M".

How to Record:

Potholes and areas of localized distress are recorded by the number of occurrences of each severity level within the sample units.

Note:

Potholes or localized failures associated with severe spalling of cracks are not recorded under this distress.

RAVELING / WEATHERING / SEGREGATION

Description:

Wearing away of the pavement surface caused by the dislodging of aggregate particles (raveling) and loss of asphalt binder (weathering). Segregation is the result of the coarse and fine components of the bituminous mix being separated in the pavement surface.

Severity Levels:

L - Wearing away of the aggregate or binder has started but has not progressed significantly.

M - Aggregate and/or binder has worn away and the surface texture is becoming rough and pitted; loose particles generally exist.

H - Aggregate and/or binder has worn away and the surface texture is very rough and pitted.

How to Record:

Unit - Lane feet. Feet along the lane of the affected area at each severity level.

REFLECTED PATCH JOINT CRACKING

Description:

Reflected patch joint cracks form along the edges of patches located in the underlying Portland cement concrete (PCC) pavement. In overlaid jointed concrete pavements these cracks usually appear as two parallel cracks less than ten feet apart and extending across the full lane width. For overlaid continuous reinforced concrete pavements and flexible pavements, the underlying patches may be of any size and shape.

Severity Levels:

L - Cracks are tight (mean width less than or equal to 1/4") with minor or no spalling present.

M - Crack width is between 1/4" and 1/2". Cracks may be moderately spalled. Low severity random parallel cracking may exist near the crack or at the intersection of cracks.

H - One or more of the following conditions exist: (1) crack width is greater than 1/2", (2) crack is severely spalled, (3) medium or severe random parallel cracking exists near the crack or at the intersection of cracks, (4) major sealing or other major maintenance activity has been performed.

How to Record:

Reflected patch joint cracking is recorded as the number of occurrences at each severity level. A crack extending at least halfway across a lane constitutes one occurrence. A crack exhibiting various levels of severity is to be recorded as the highest level of severity present. If it is uncertain whether the crack is caused by an underlying patch, it should be treated as Transverse Cracking .

Note:

Most sealed cracks are of high severity because of original crack width and/or severe spalling. In some cases, low and medium severity cracks have been sealed for preventive maintenance.

TRANSVERSE CRACKING

Description:

Transverse cracks extend across the pavement perpendicular to the centerline. They are caused by cracks in the underlying pavement or stabilized base reflecting through the bituminous surface. The cracks may also be due to thermal cracking of the bituminous surface. Transverse cracking is usually not as straight as "Transverse Joint Reflection Cracking".

Severity Levels:

L - Cracks are tight (mean width less than or equal to 1/4") with minor or no spalling present.

M - Crack width is between 1/4" and 1/2". Cracks may be moderately spalled. Low severity random parallel cracking may exist near the crack or at the intersection of cracks.

H - One or more of the following conditions exist: (1) crack width is greater than 1/2", (2) crack is severely spalled, (3) medium or severe random parallel cracking exists near the crack or at the intersection of cracks, (4) major sealing or other major maintenance activity has been performed.

How to Record:

Transverse cracking is recorded as the number of occurrences at each severity level. A crack extending at least halfway across a lane constitutes one occurrence. A crack exhibiting various levels of severity is to be recorded as the highest level present.

Note:

Most sealed cracks are of high severity because of original crack width and/or severe spalling. In some cases, low and medium severity cracks have been sealed for preventive maintenance.

APPENDIX E

Rubberized Asphalt Pavement Distresses

Alligator Cracking

Rubberized Asphalt Pavements

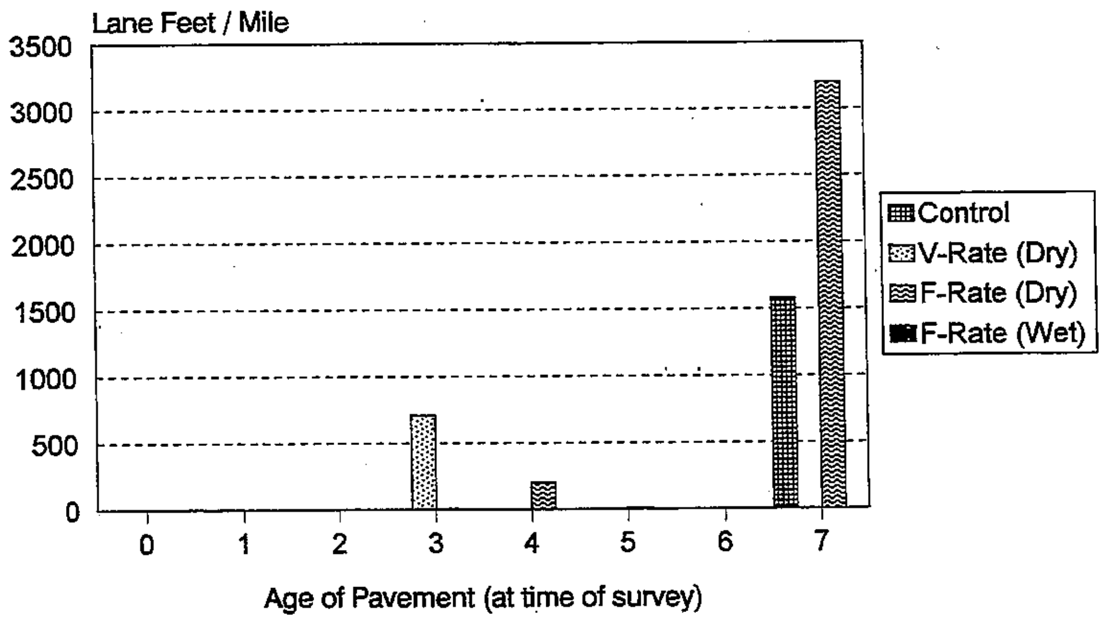


Figure E-1

Bleeding

Rubberized Asphalt Pavements

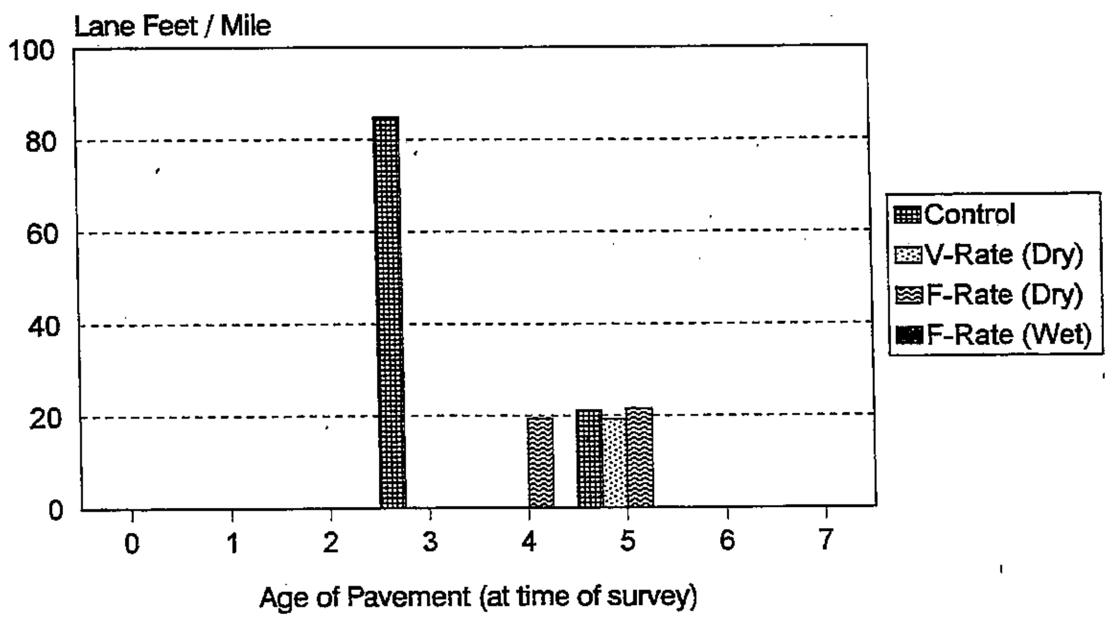


Figure E-2

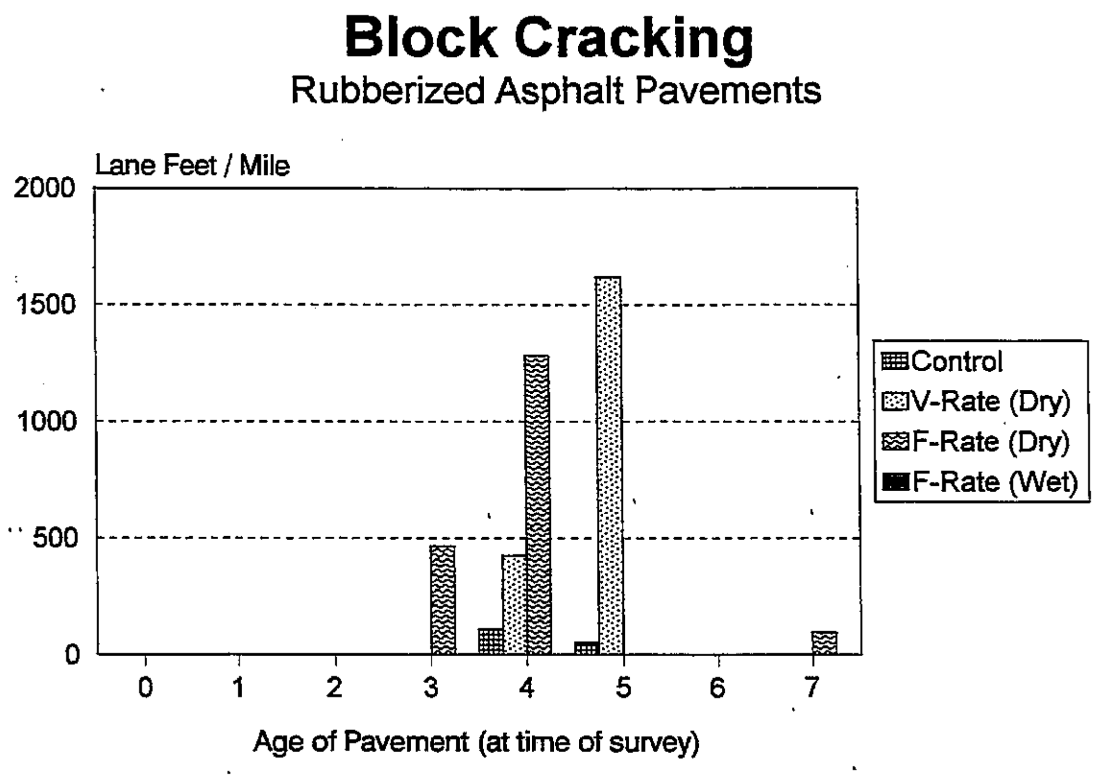


Figure E-3

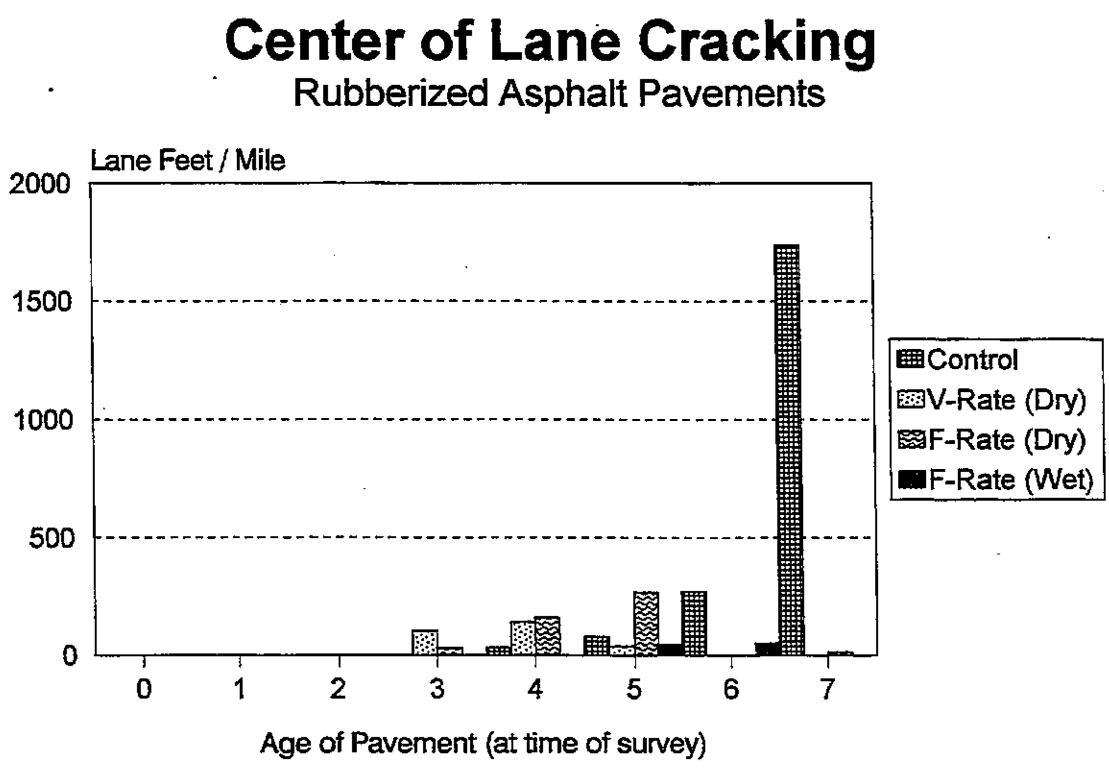


Figure E-4

Centerline Cracking
Rubberized Asphalt Pavements

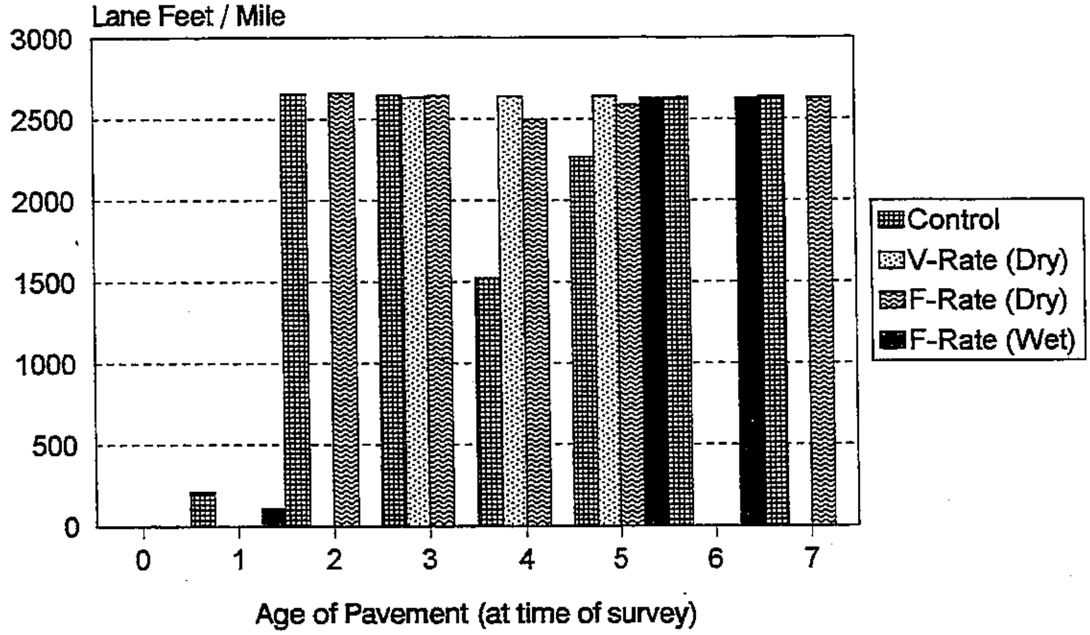


Figure E-5

Longitudinal Cracking
Rubberized Asphalt Pavements

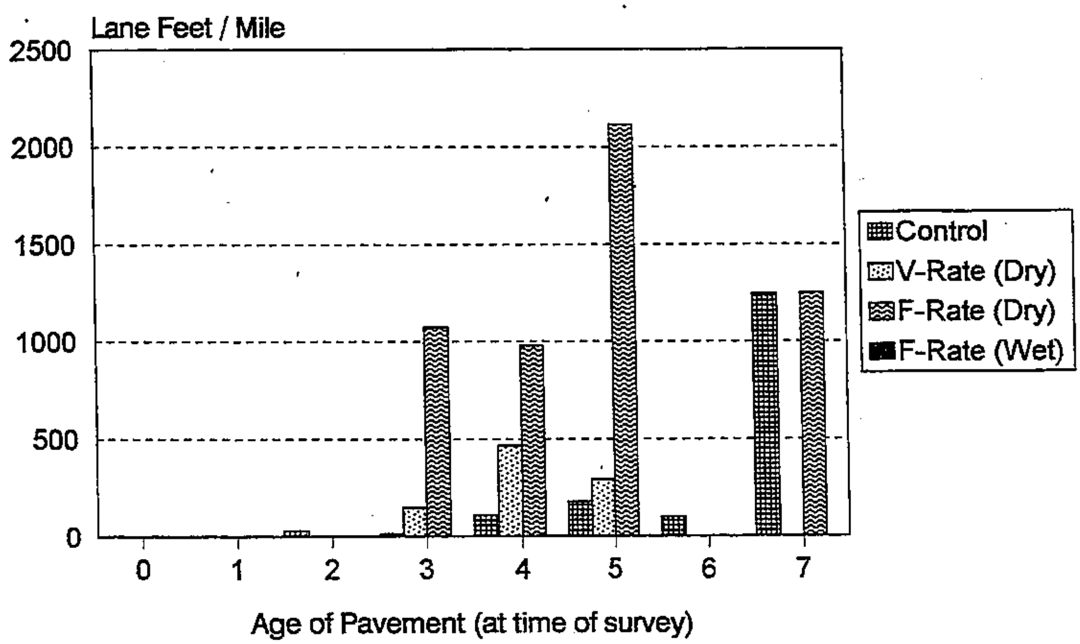


Figure E-6

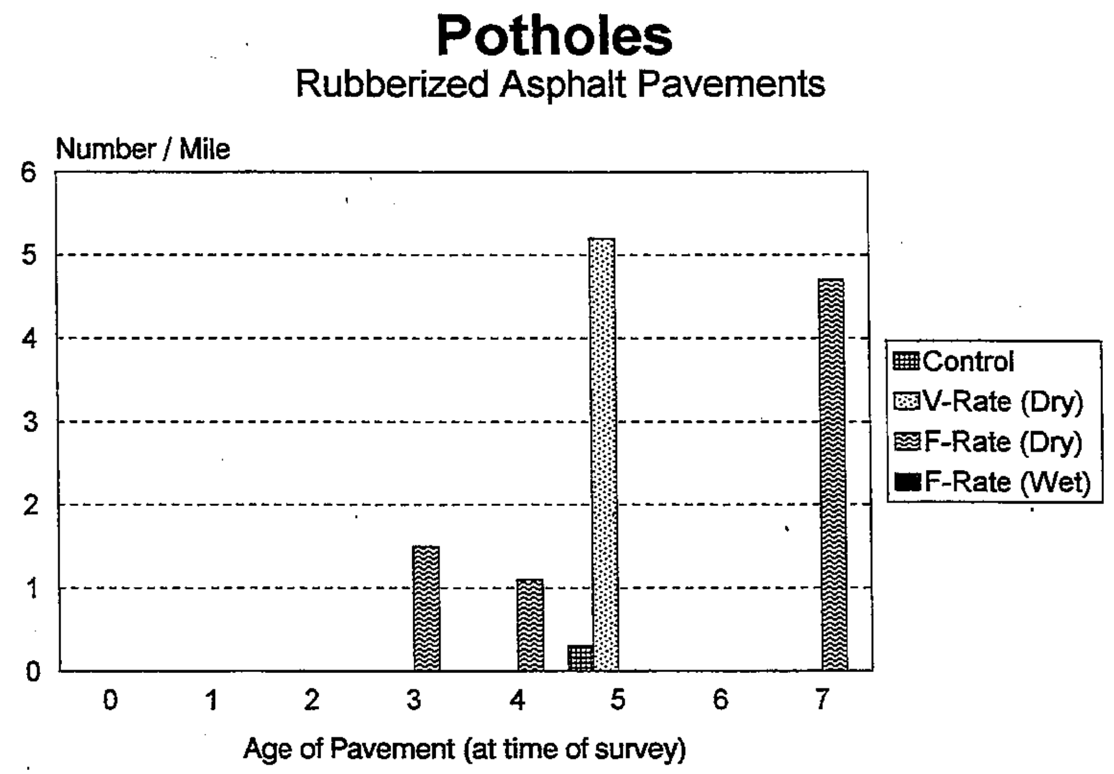


Figure E-7

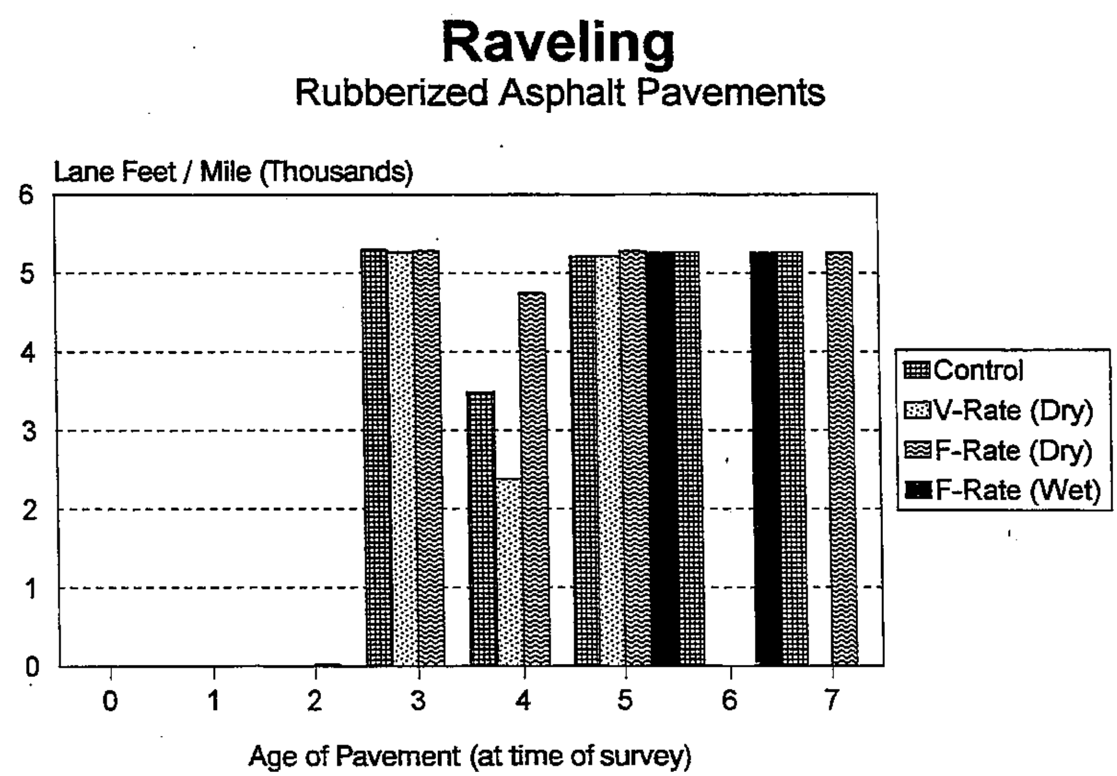


Figure E-8

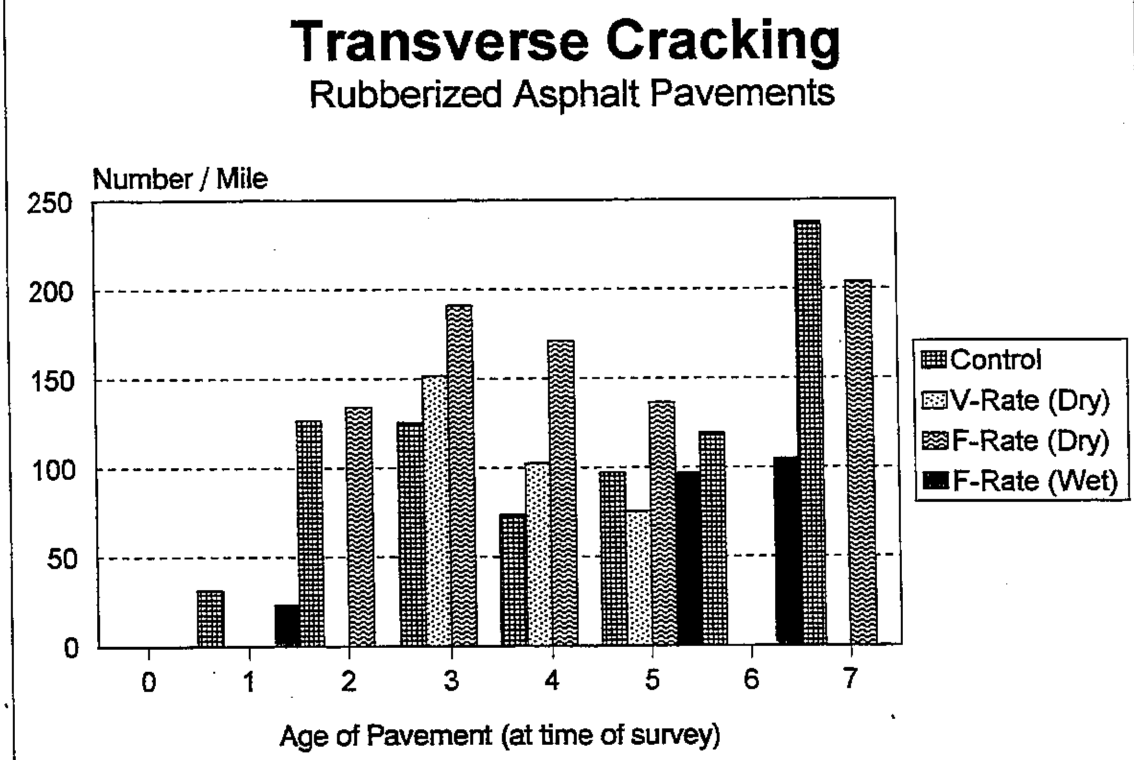

Transverse Cracking
Rubberized Asphalt Pavements
Number / Mile
250
200
150
100
50
0
0
1
2
3
4
5
6
7
Age of Pavement (at time of survey)
Control
V-Rate (Dry)
F-Rate (Dry)
F-Rate (Wet)

Figure E-9

APPENDIX F

Individual Project Distresses

Alligator Cracking

Project A

Control & Fixed Rate (Dry)

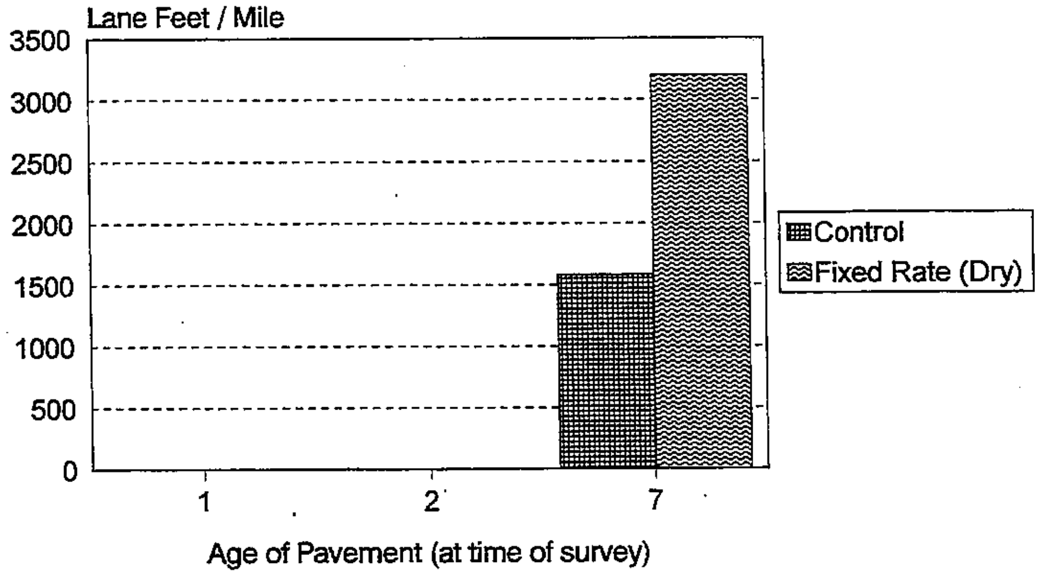


Figure F-1

Block Cracking

Project A

Control & Fixed Rate (Dry)

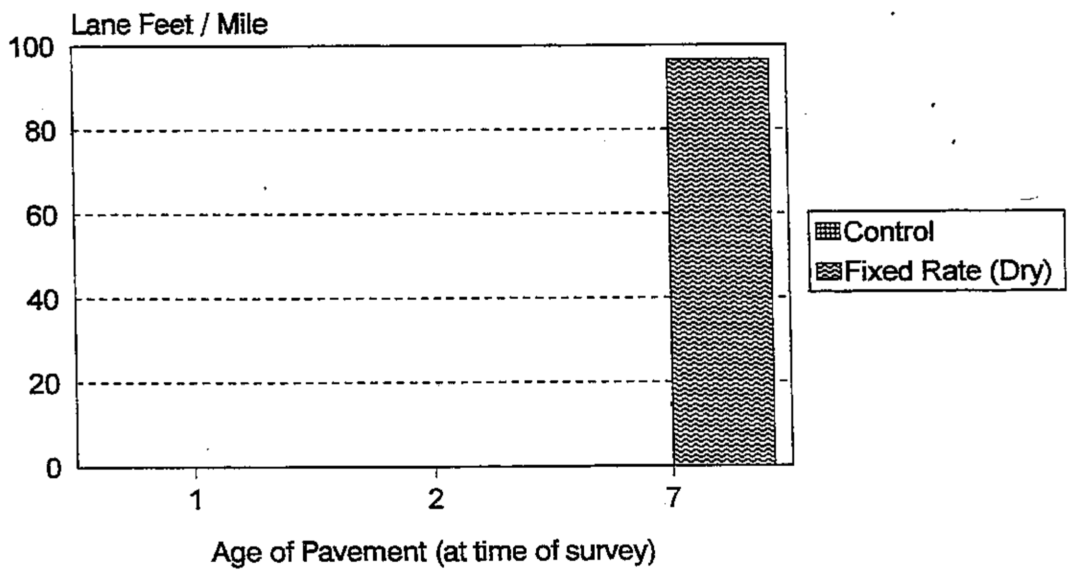


Figure F-2

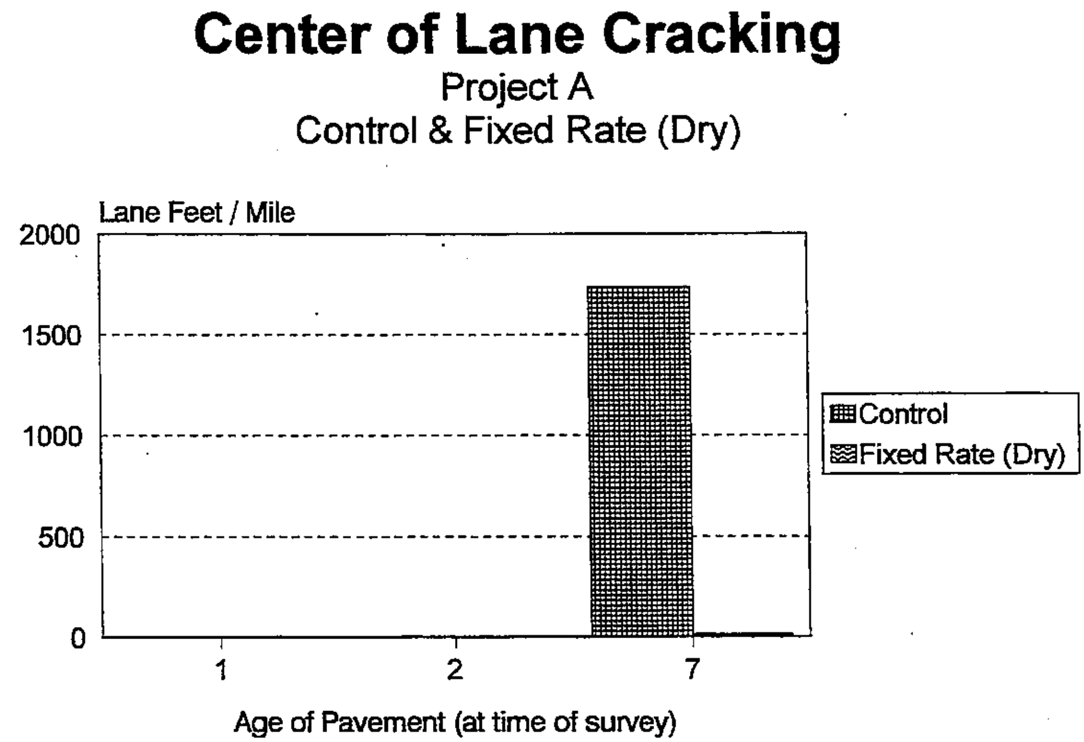


Figure F-3

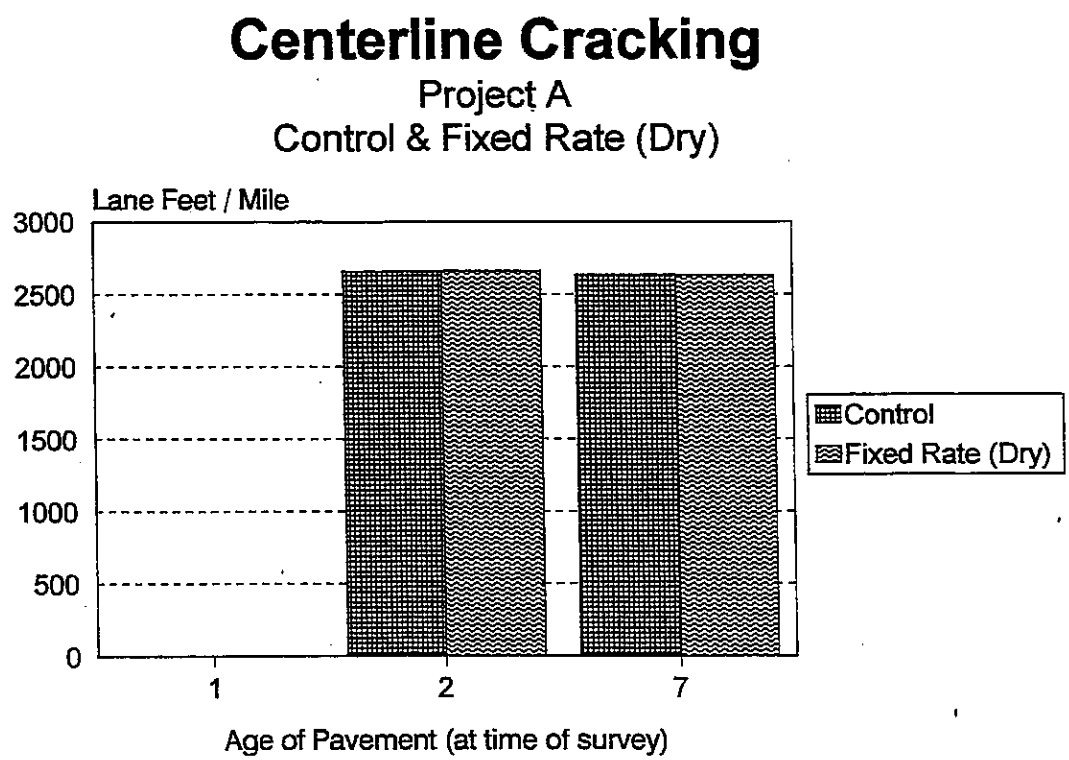


Figure F-4

Longitudinal Cracking

Project A
Control & Fixed Rate (Dry)

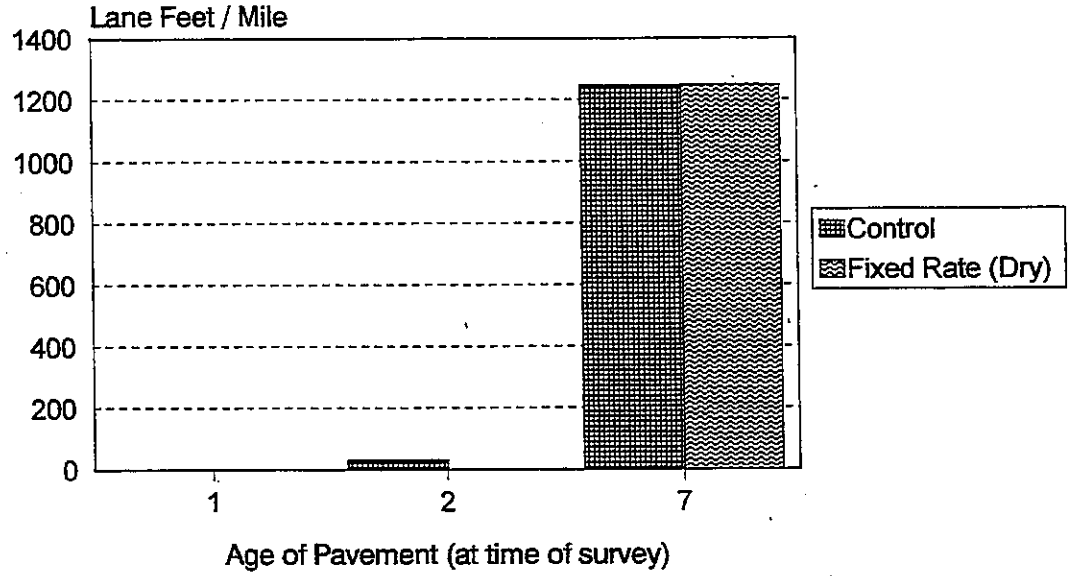


Figure F-5

Potholes

Project A
Control & Fixed Rate (Dry)

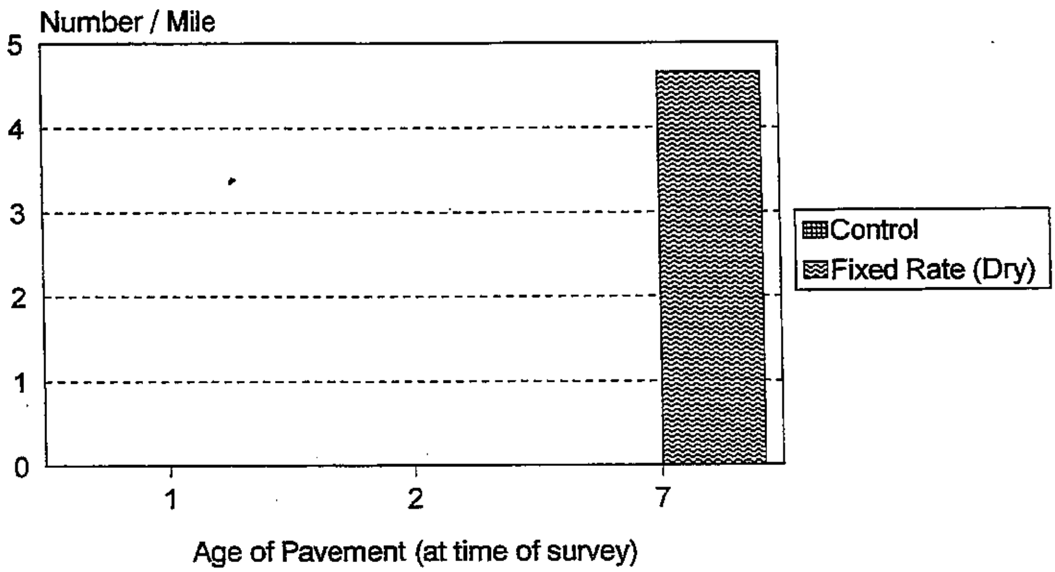


Figure F-6

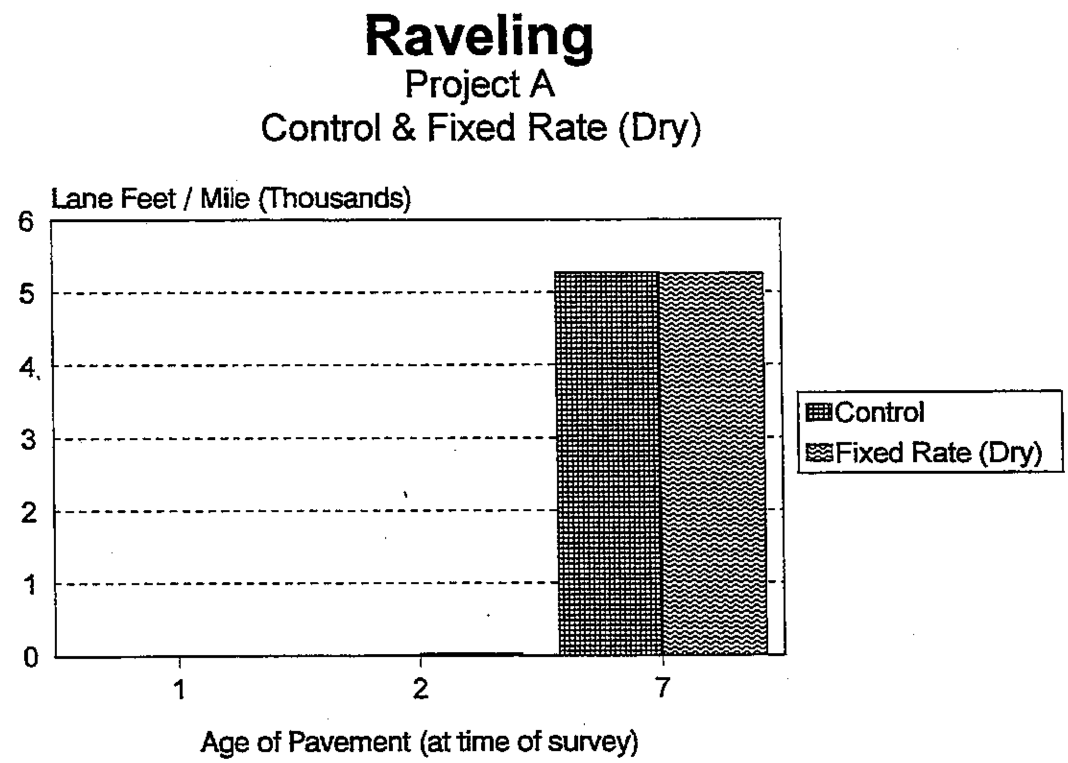


Figure F-7

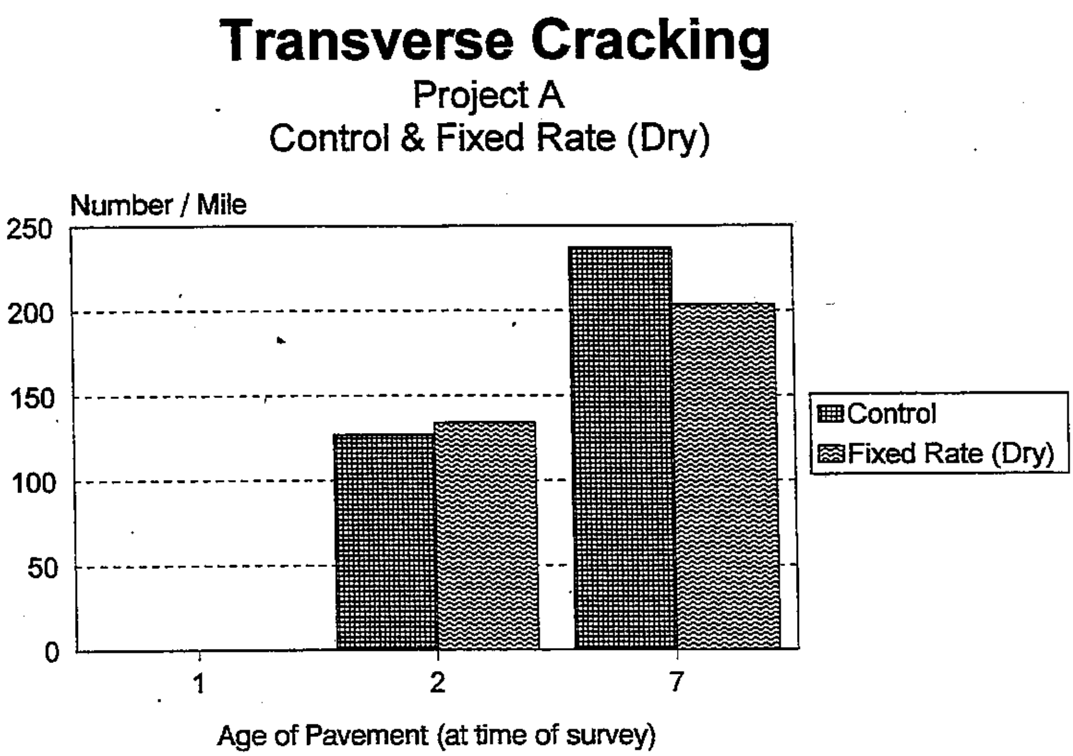


Figure F-8

Center of Lane Cracking
Project B
Control & Fixed Rate (Wet)

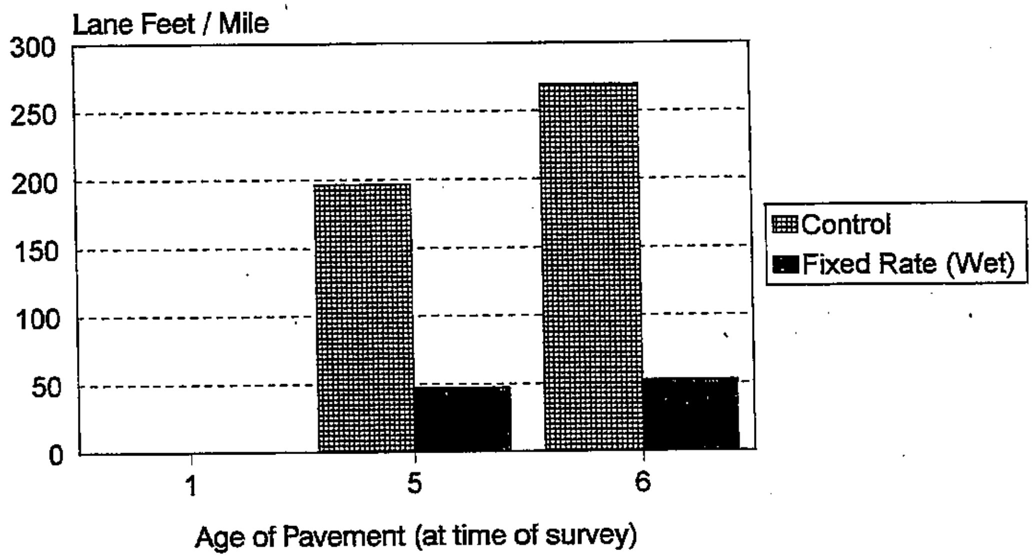


Figure F-9

Centerline Cracking
Project B
Control & Fixed Rate (Wet)

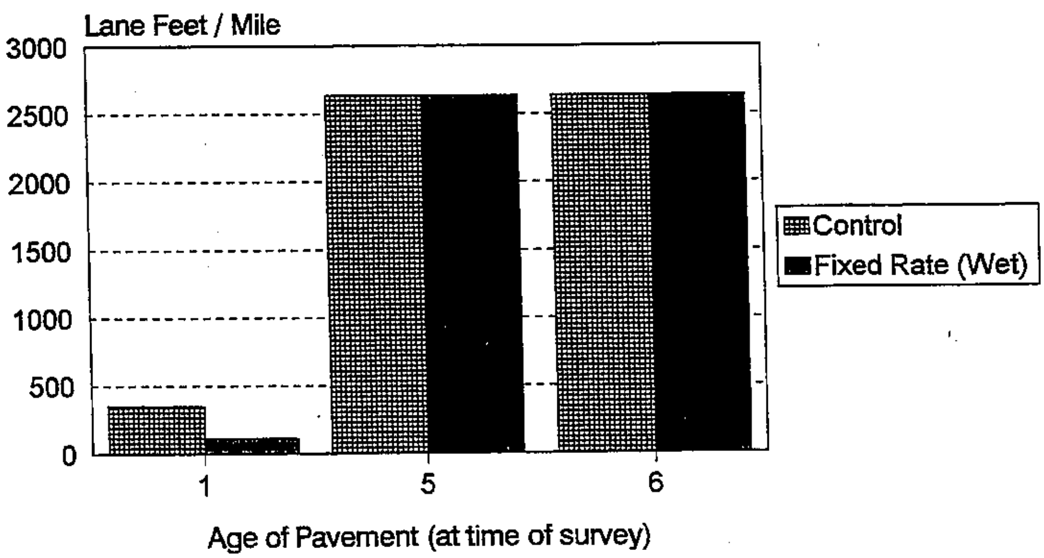


Figure F-10

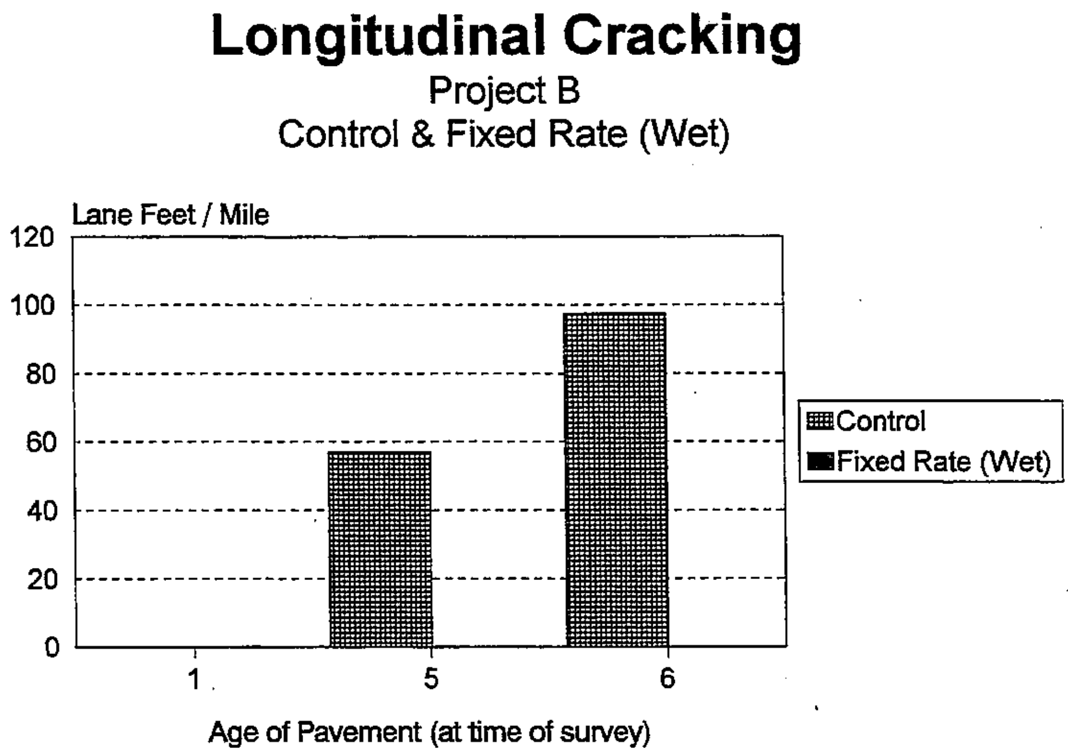


Figure F-11

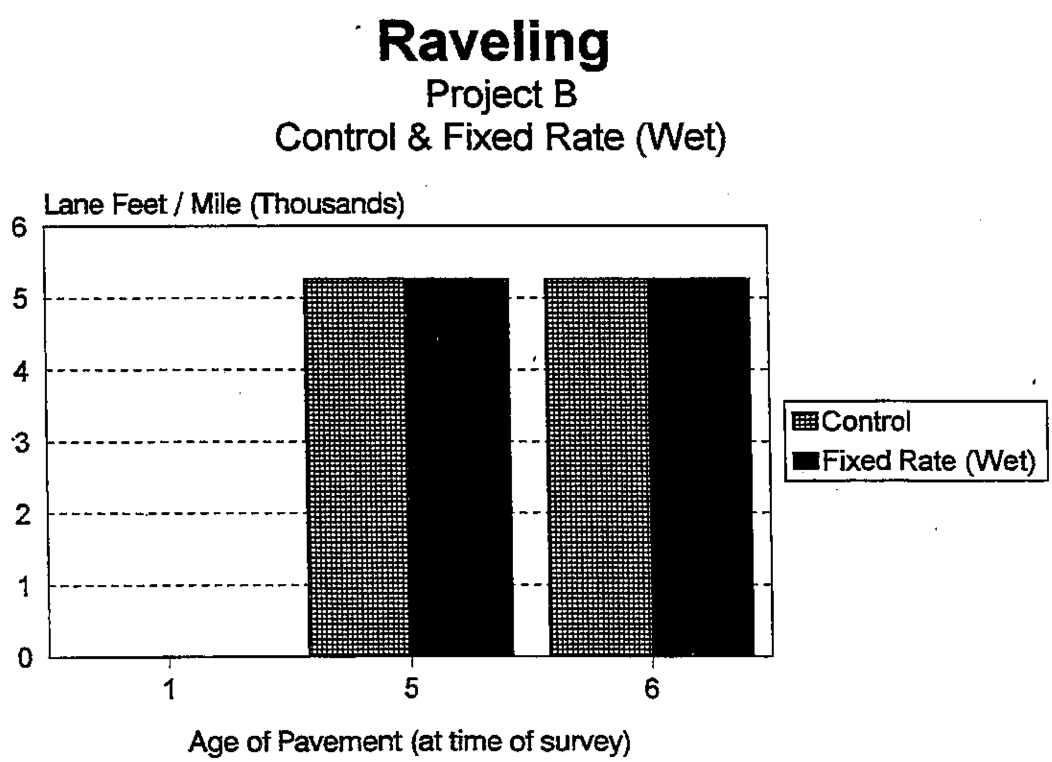


Figure F-12

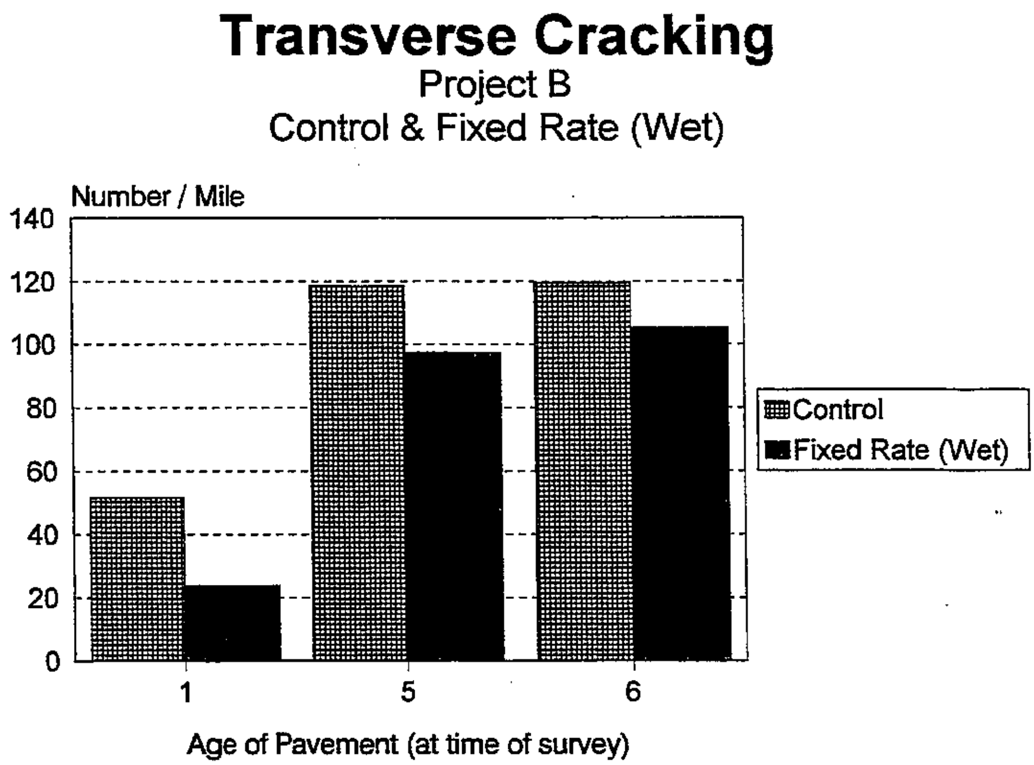


Figure F-13

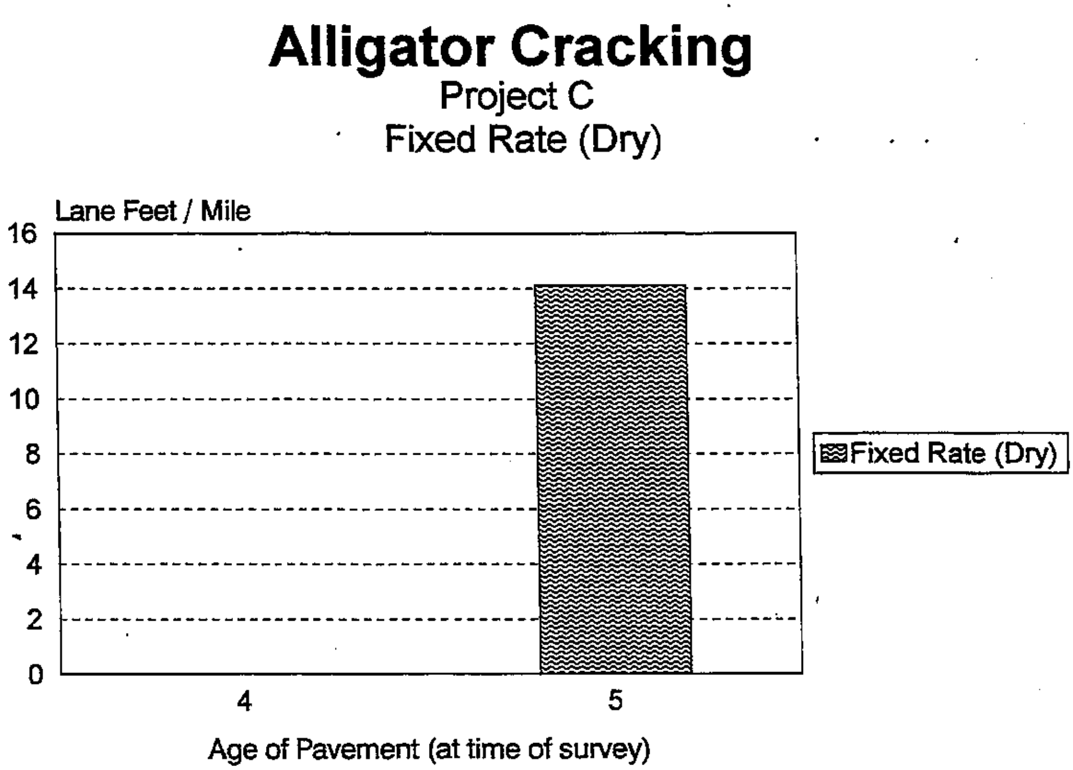


Figure F-14

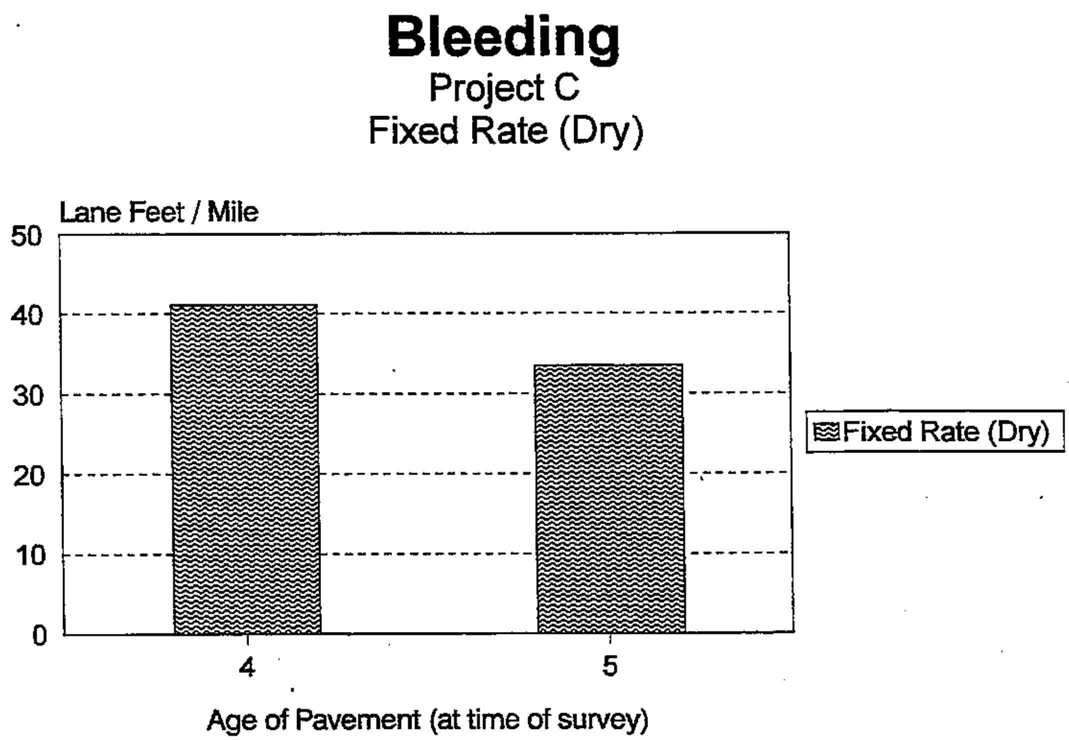


Figure F-15

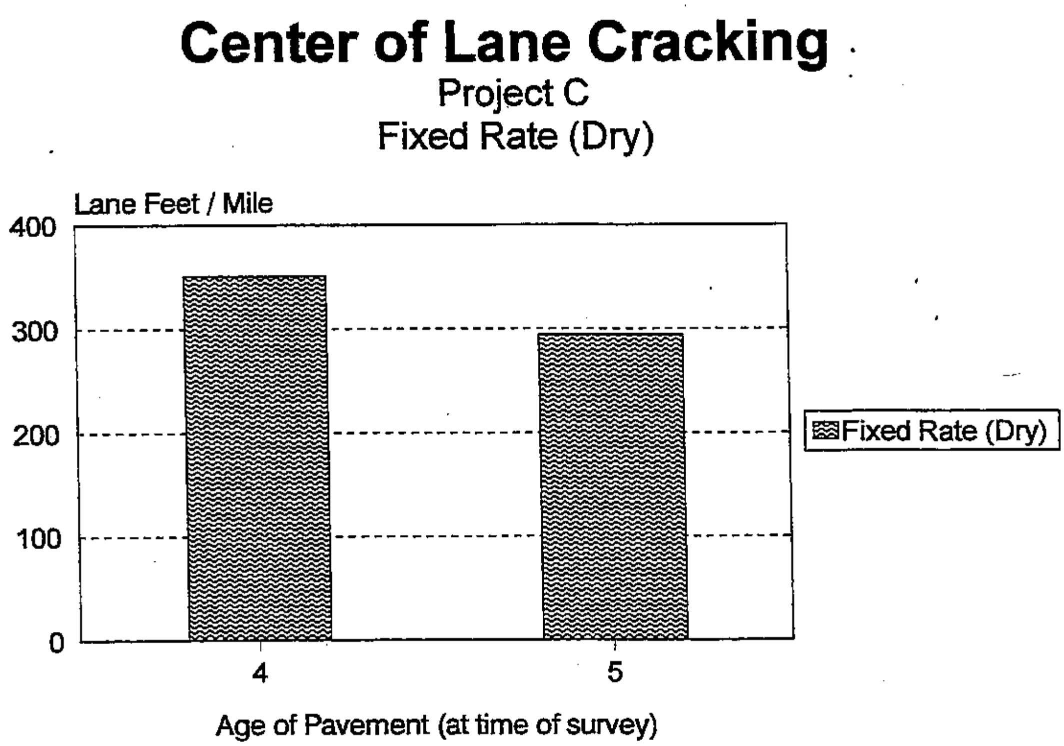


Figure F-16

Centerline Cracking
Project C
Fixed Rate (Dry)

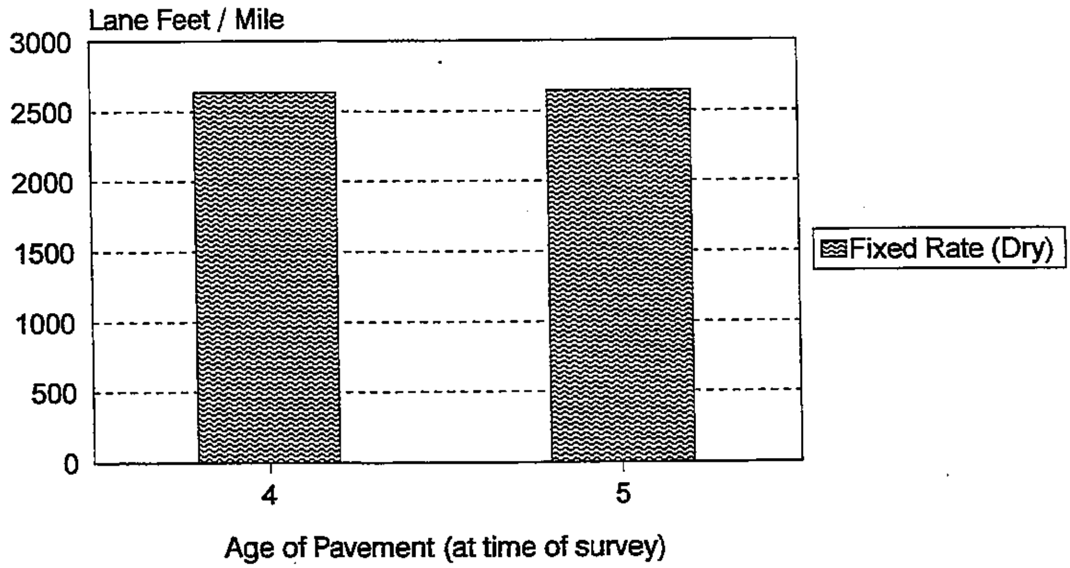


Figure F-17

Longitudinal Cracking
Project C
Fixed Rate (Dry)

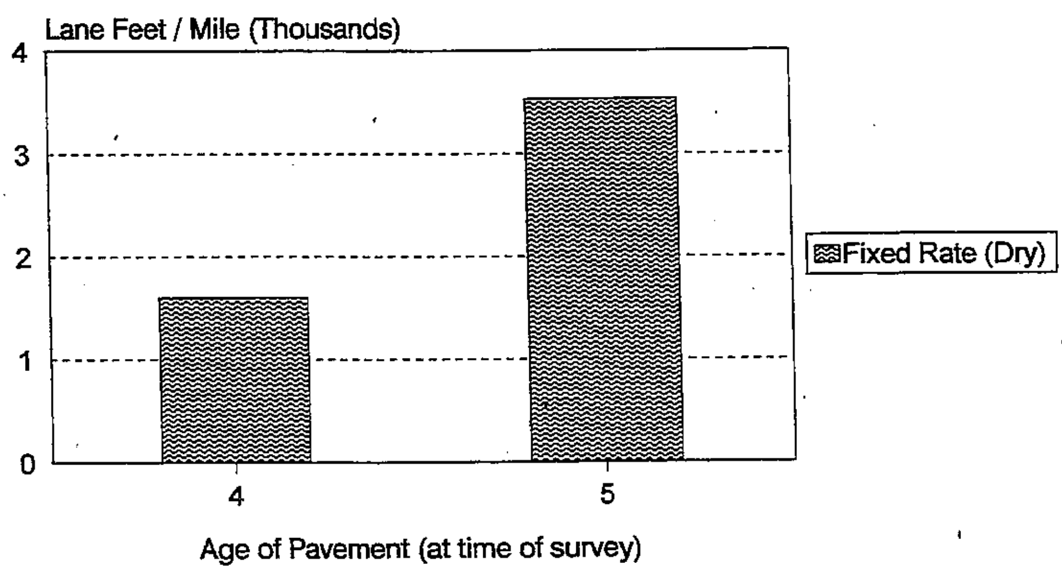


Figure F-18

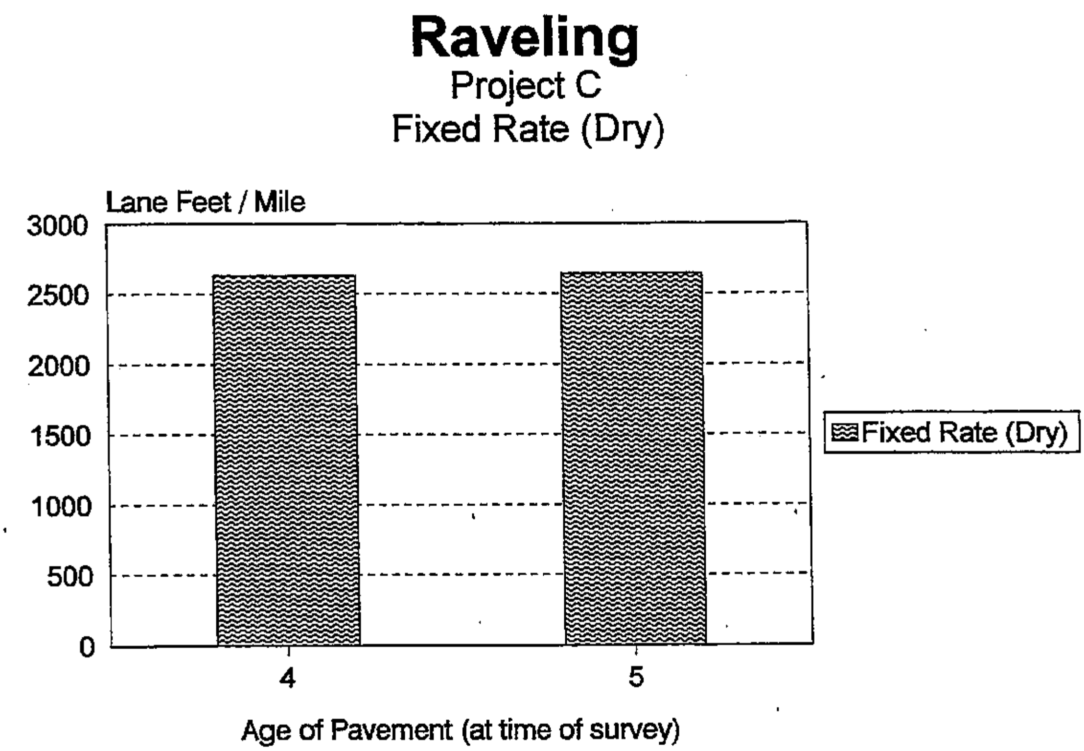


Figure F-19

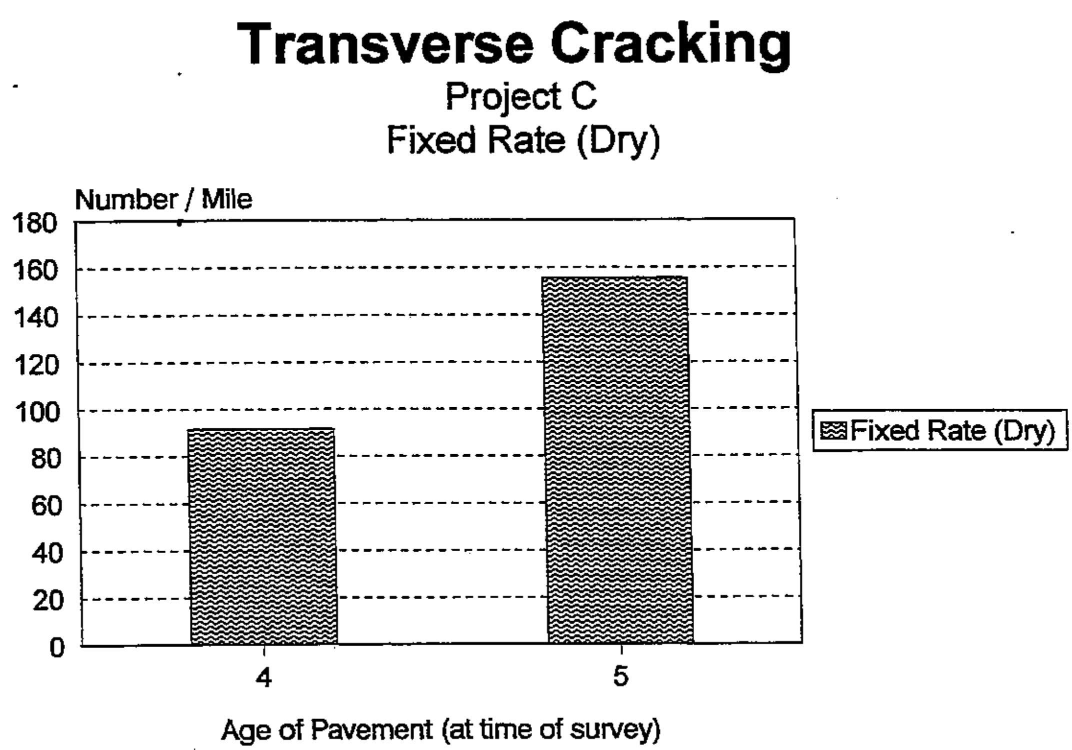


Figure F-20

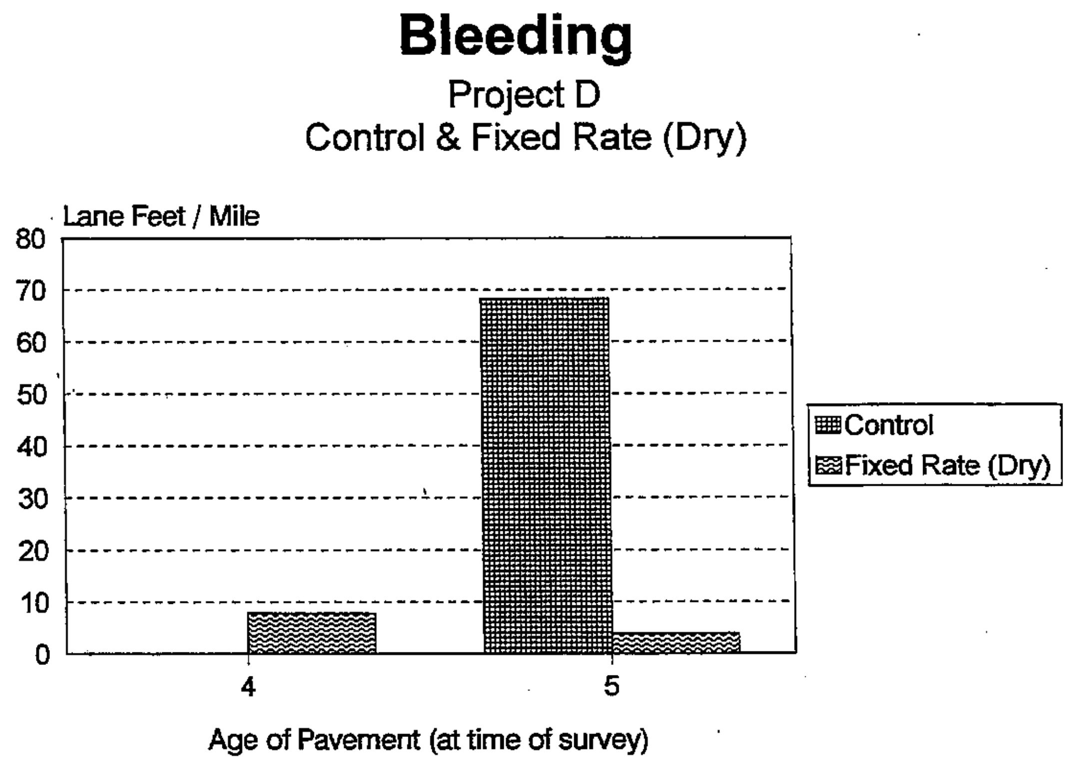


Figure F-21

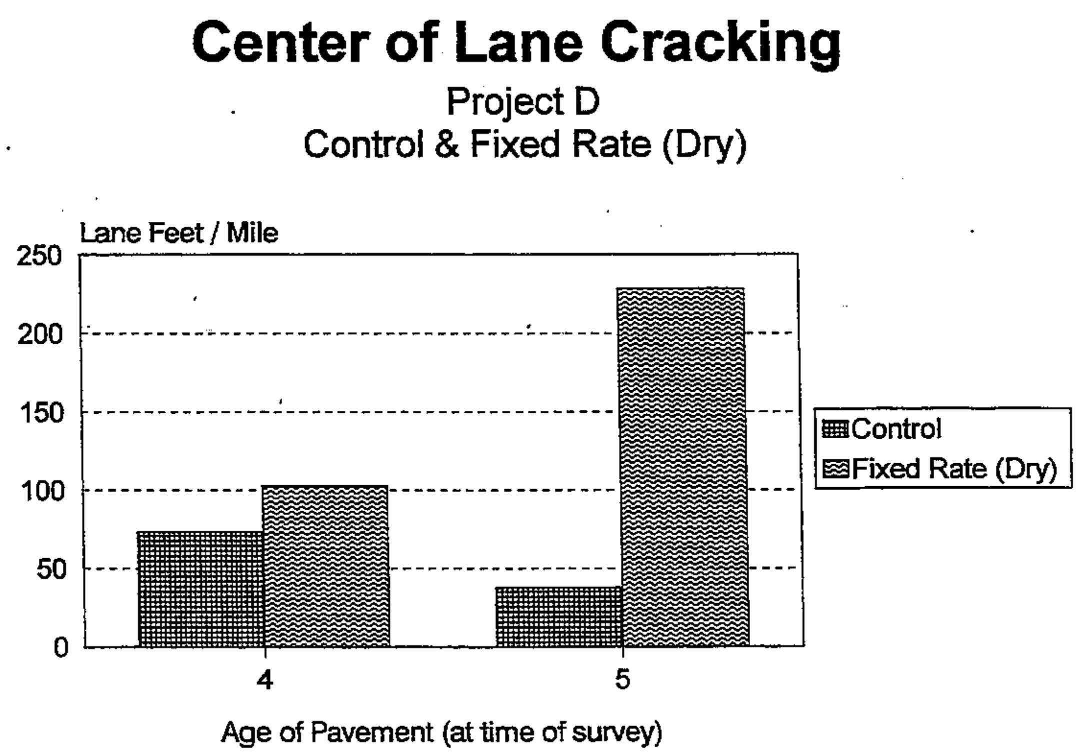


Figure F-22

Centerline Cracking
Project D
Control & Fixed Rate (Dry)

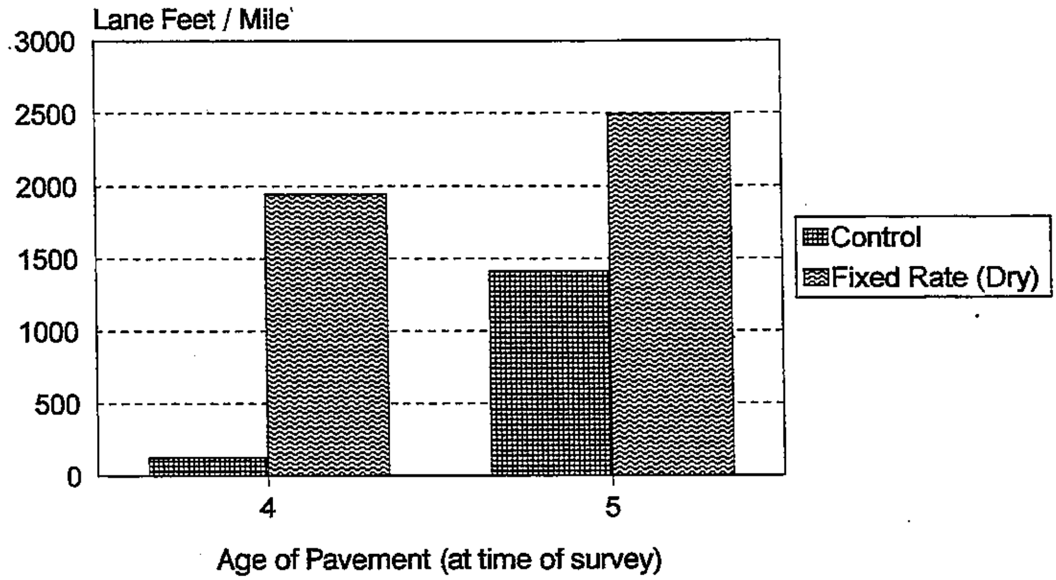


Figure F-23

Longitudinal Cracking
Project D
Control & Fixed Rate (Dry)

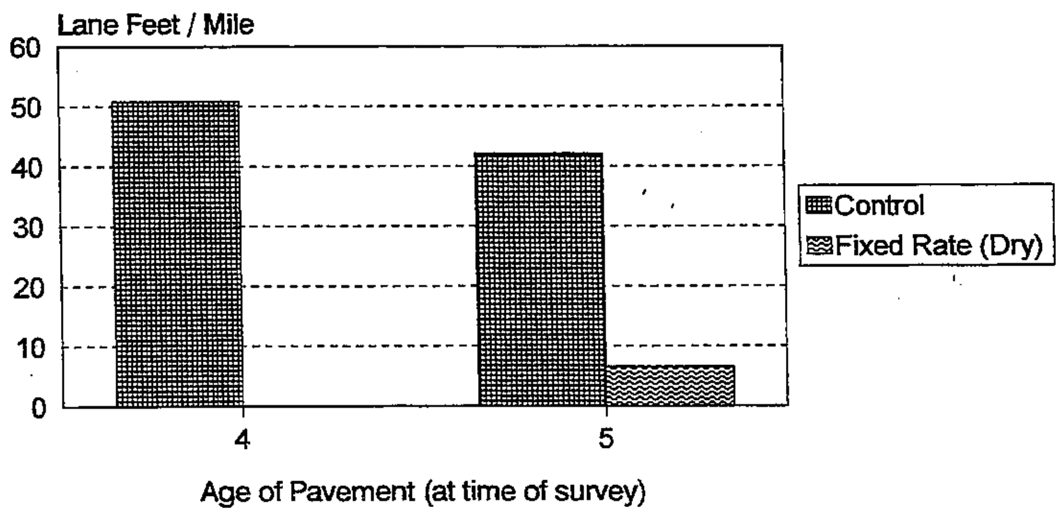


Figure F-24

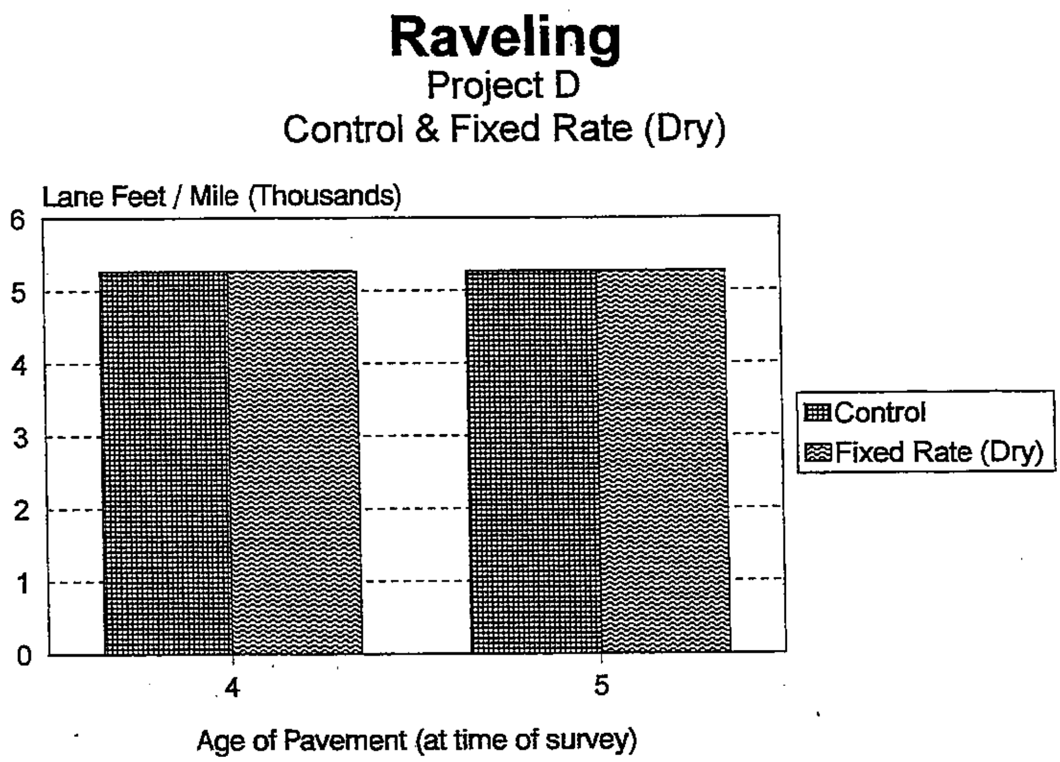


Figure F-25

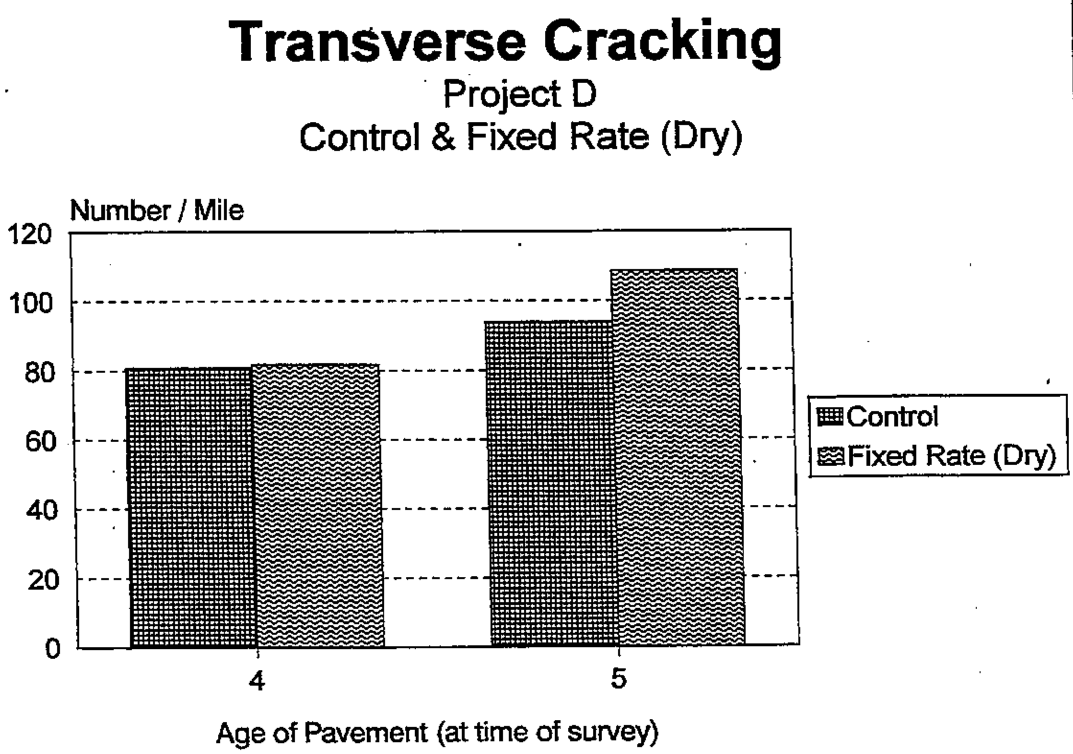


Figure F-26

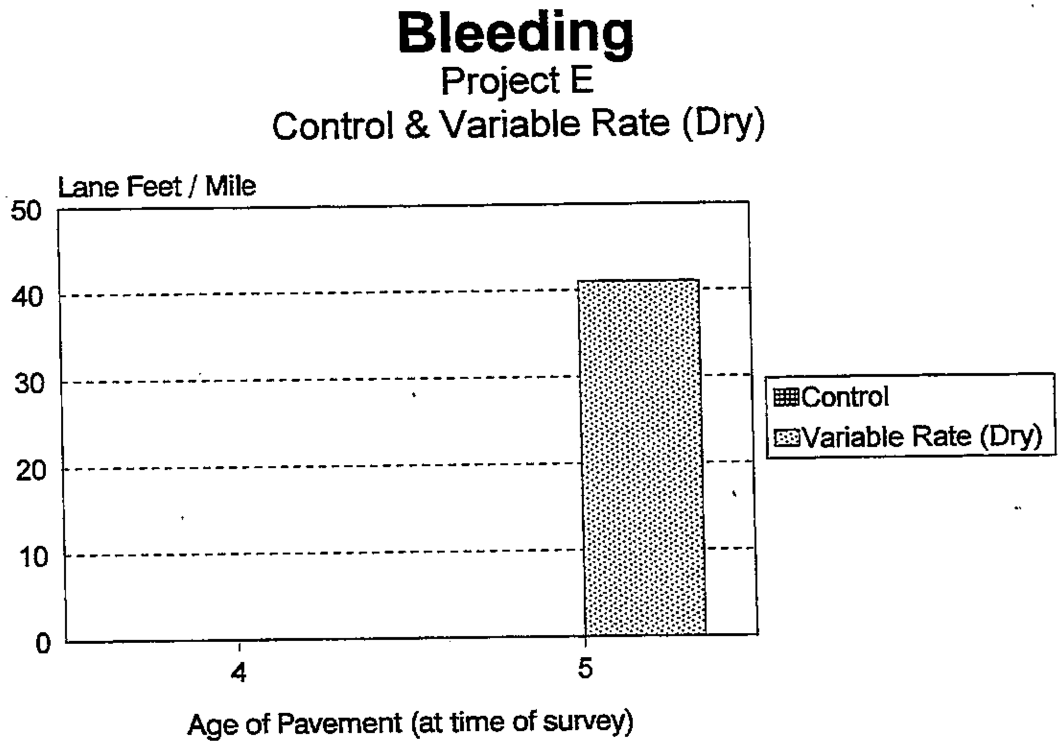


Figure F-27

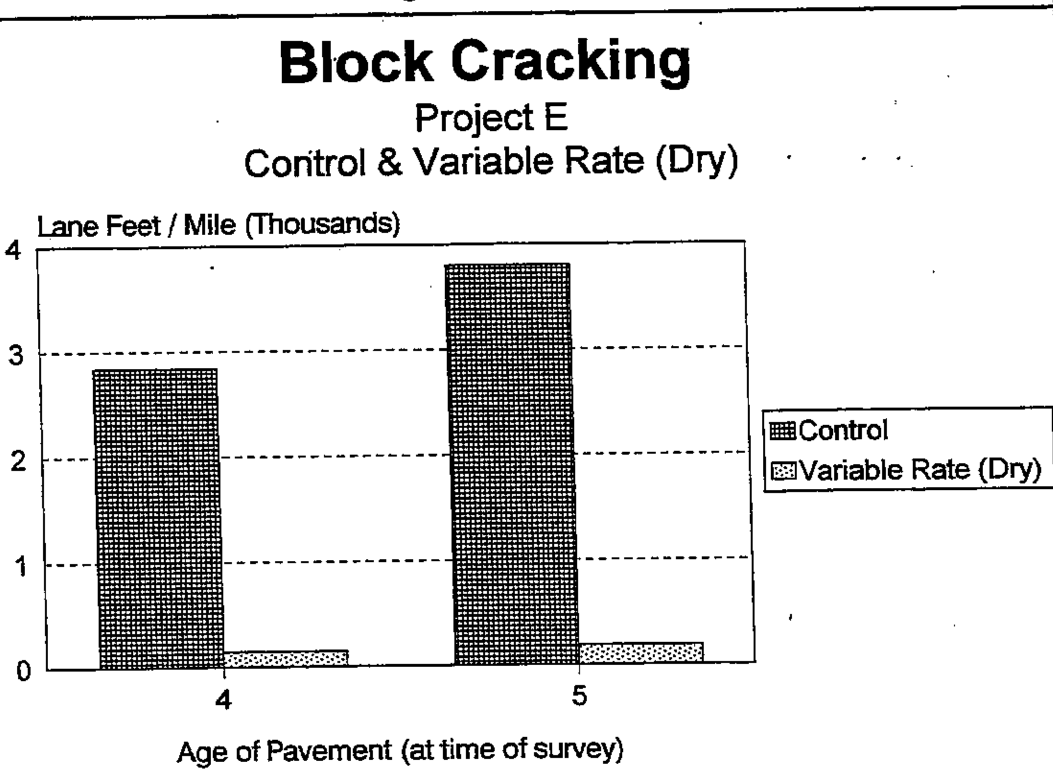


Figure F-28

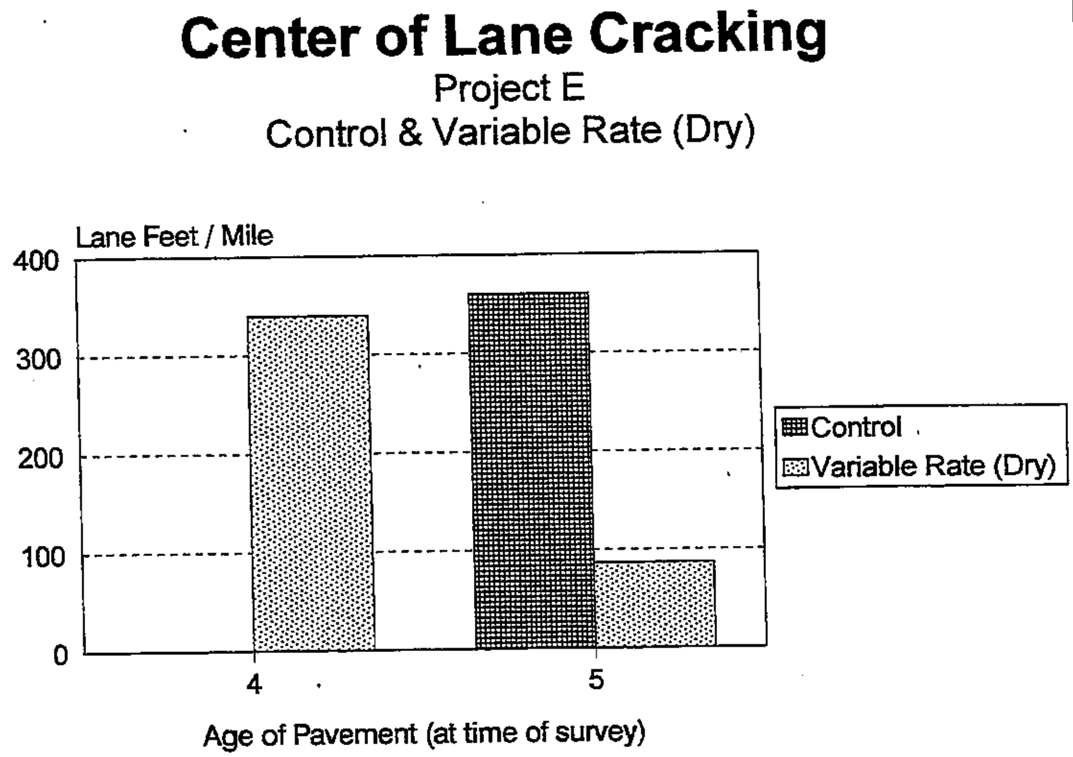


Figure F-29

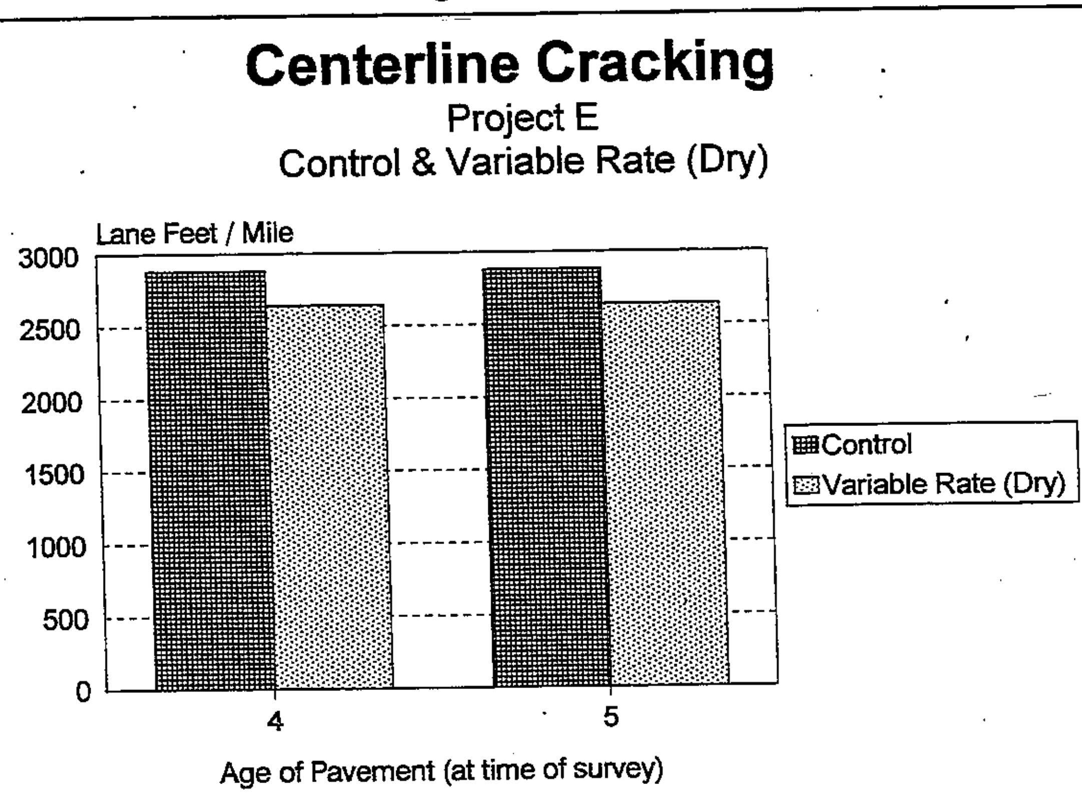


Figure F-30

Longitudinal Cracking
Project E
Control & Variable Rate (Dry)

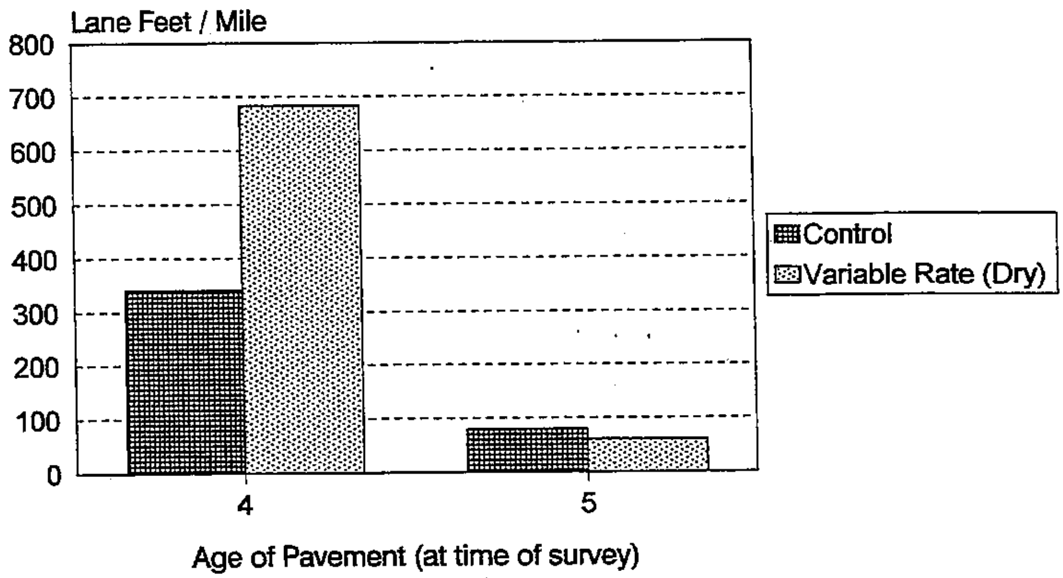


Figure F-31

Raveling
Project E
Control & Variable Rate (Dry)

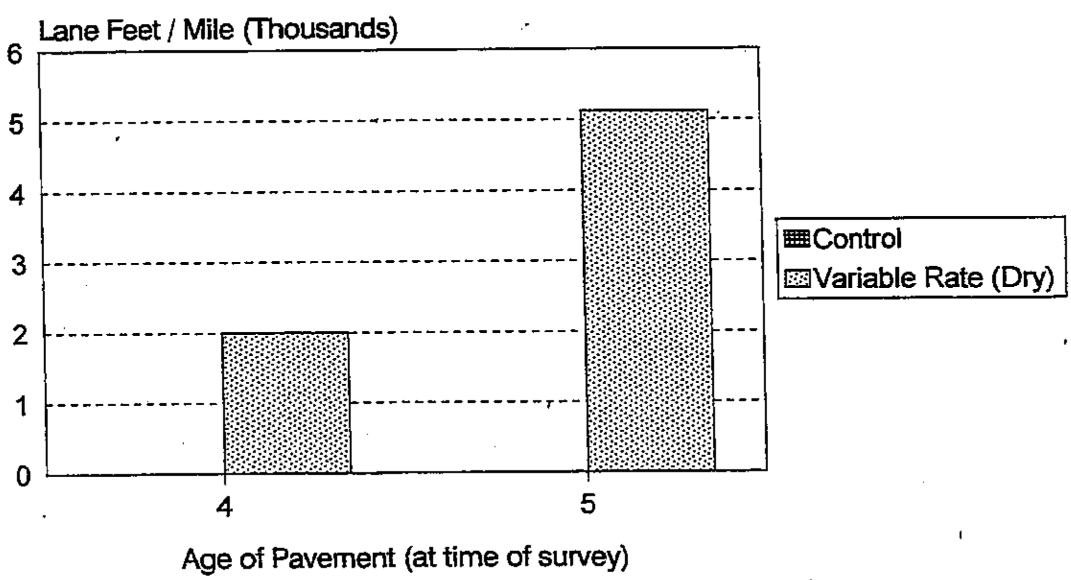


Figure F-32

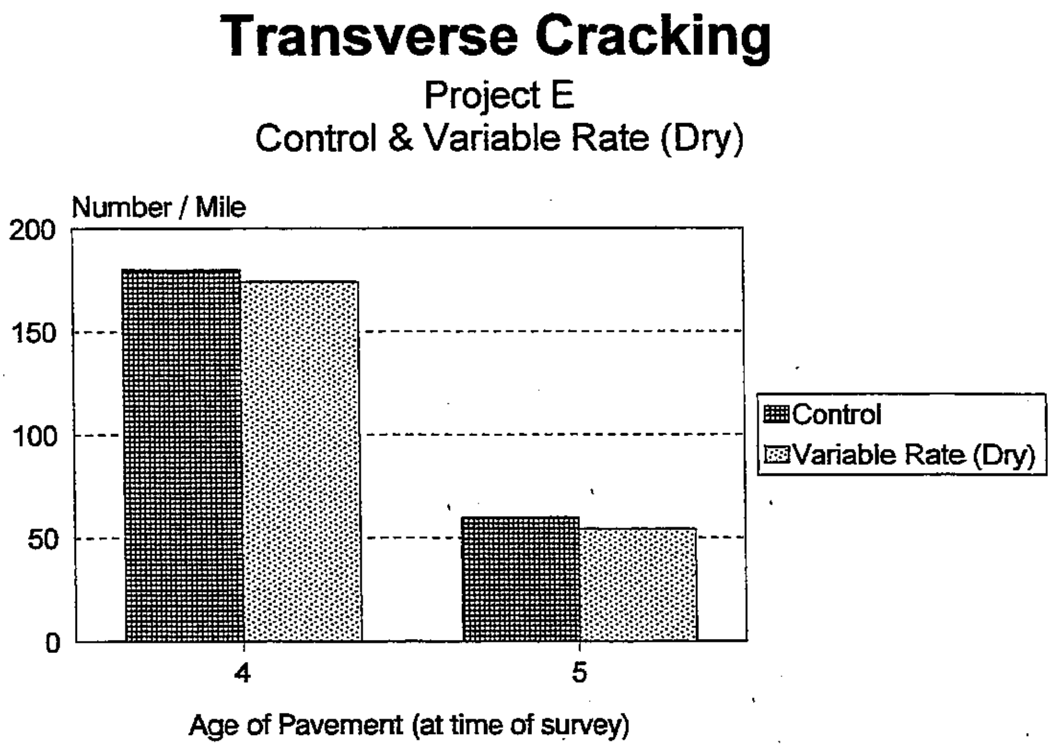


Figure F-33

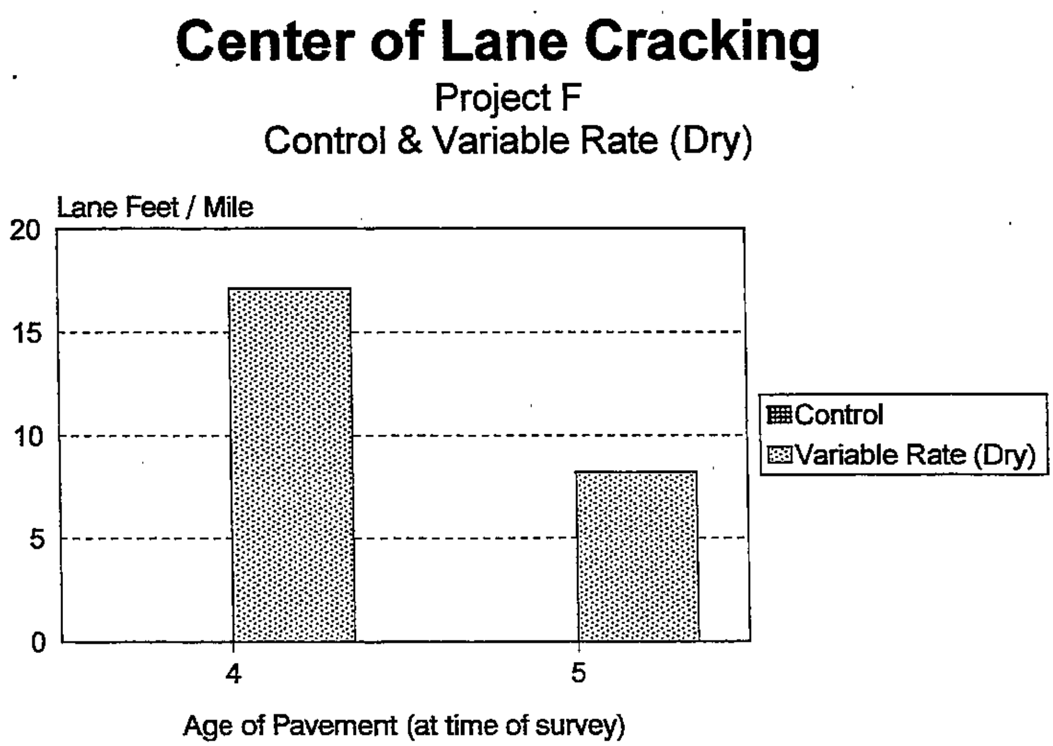


Figure F-34

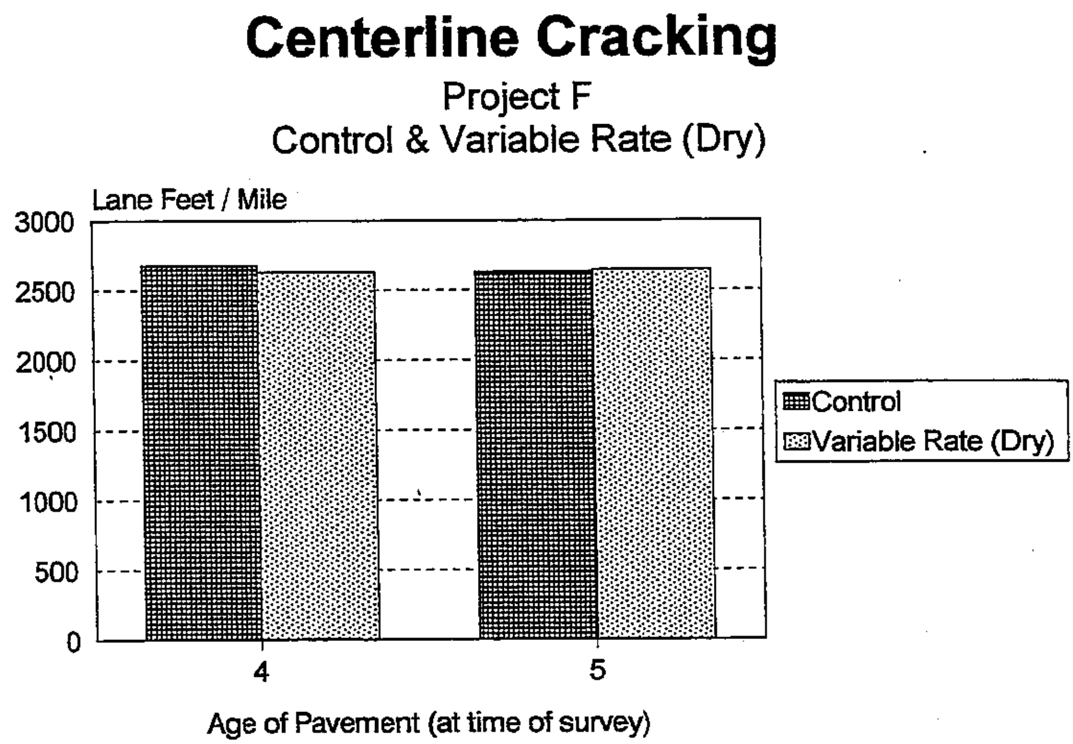


Figure F-35

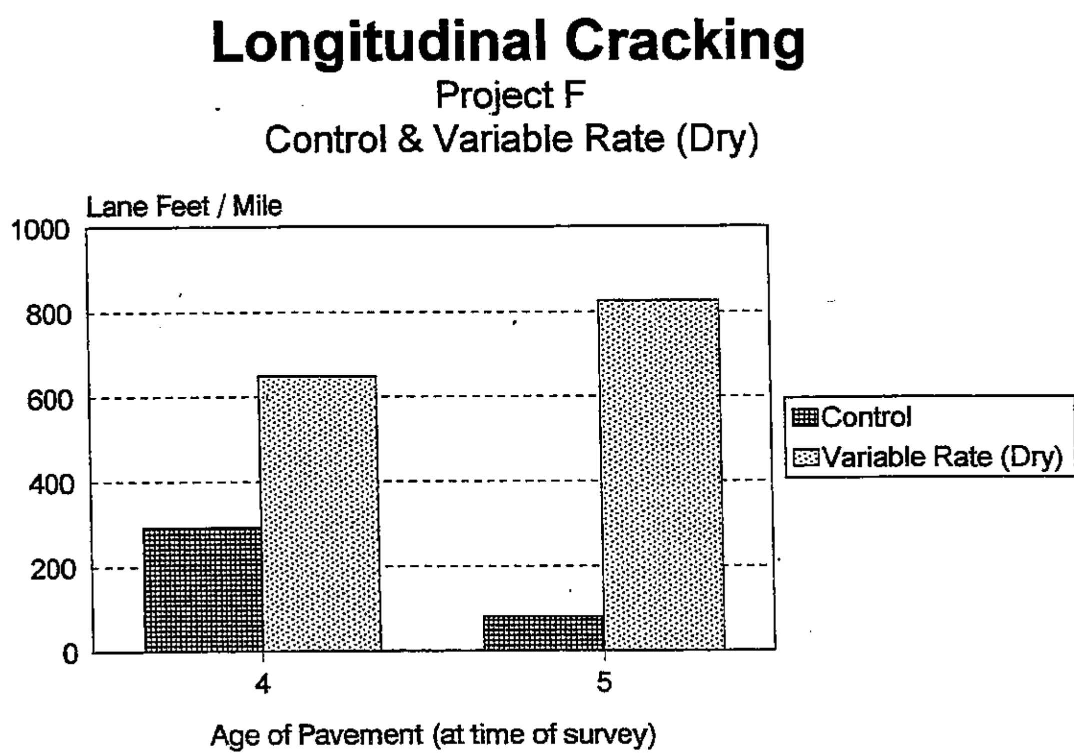


Figure F-36

Potholes

Project F
Control & Variable Rate (Dry)

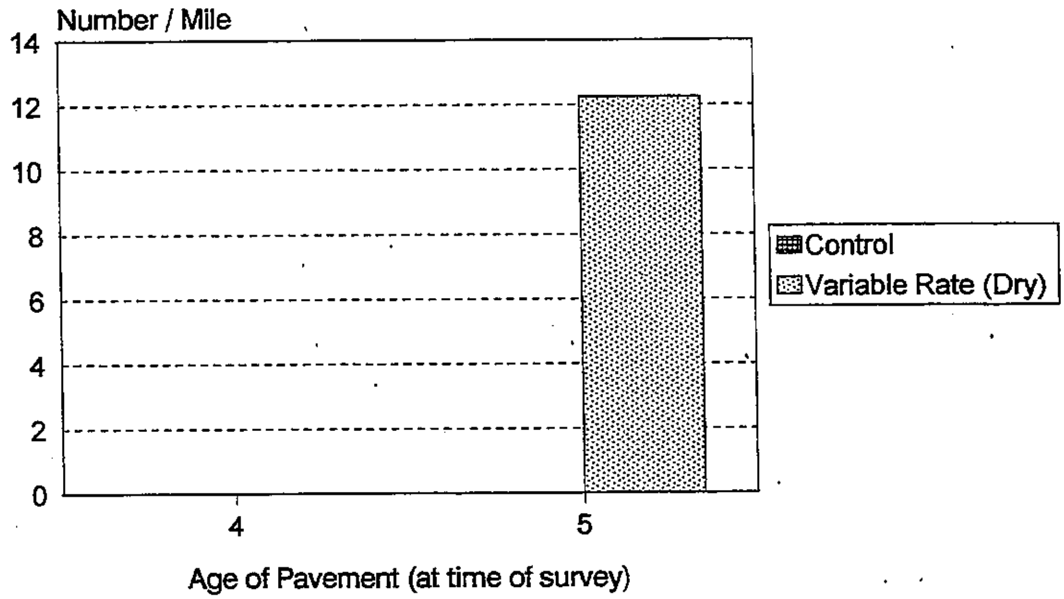


Figure F-37

Raveling

Project F
Control & Variable Rate (Dry)

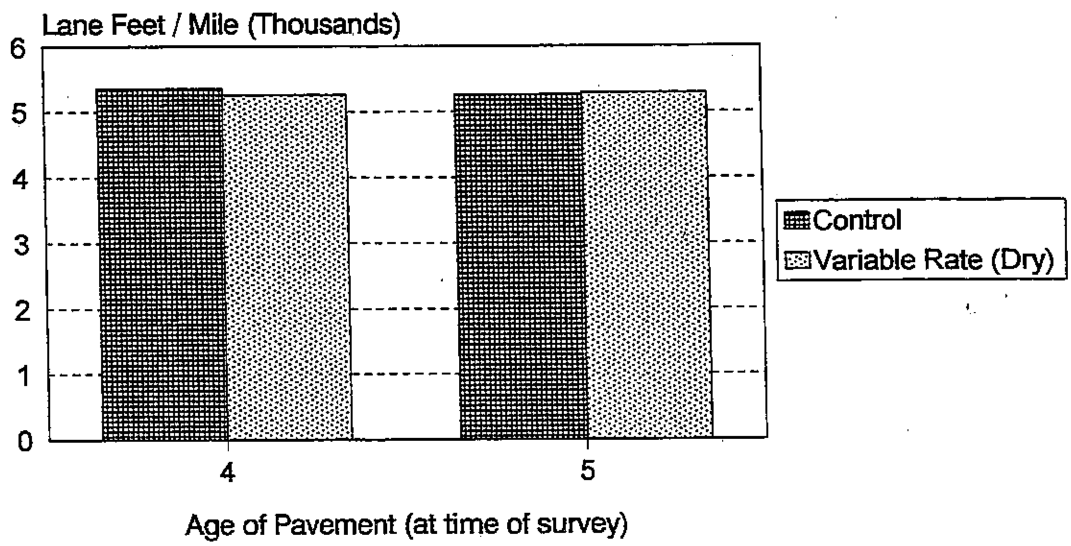


Figure F-38

Transverse Cracking

Project F

Control & Variable Rate (Dry)

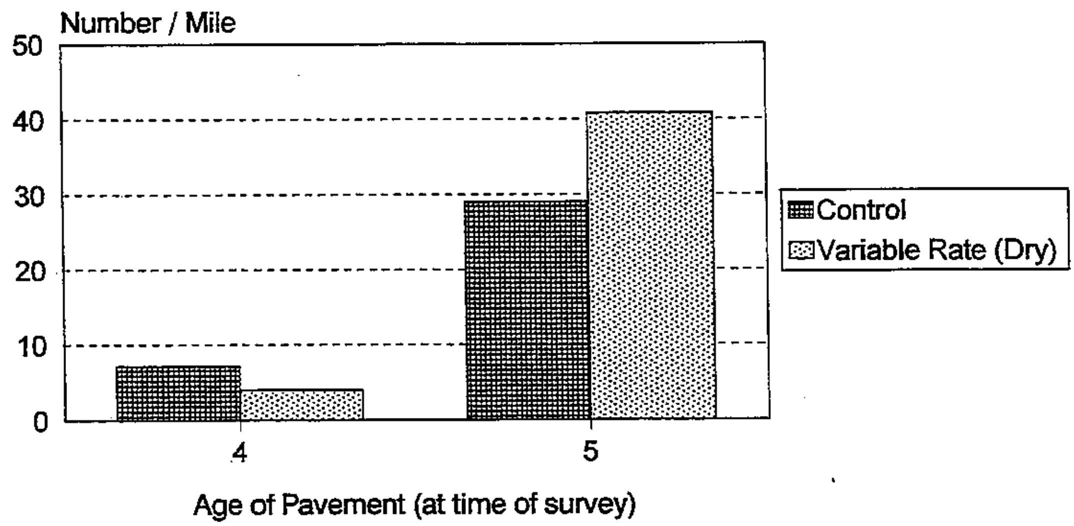


Figure F-39

Centerline Cracking

Project G

Control & Variable Rate (Dry)

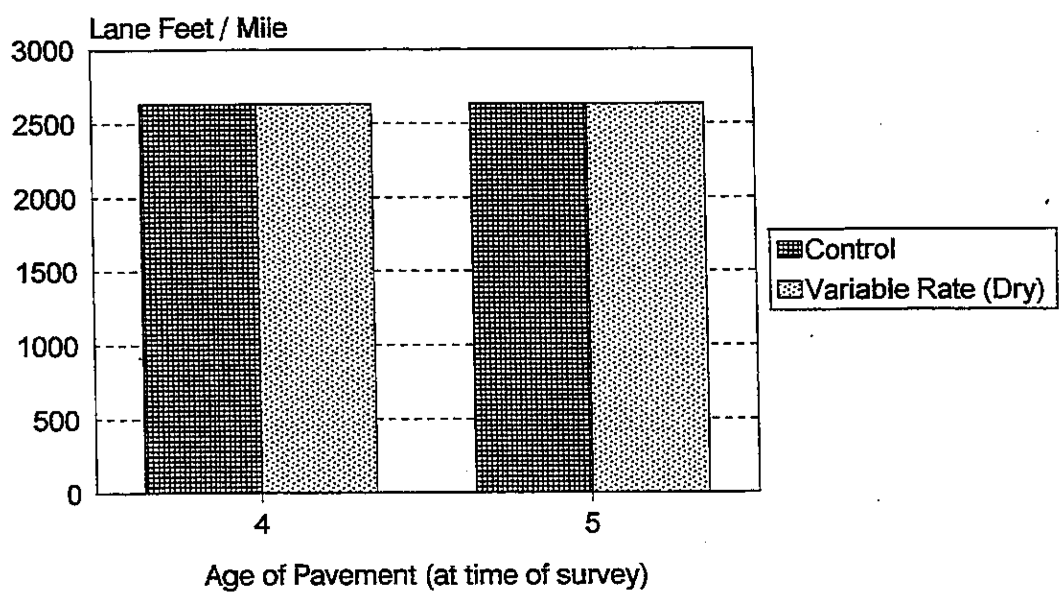


Figure F-40

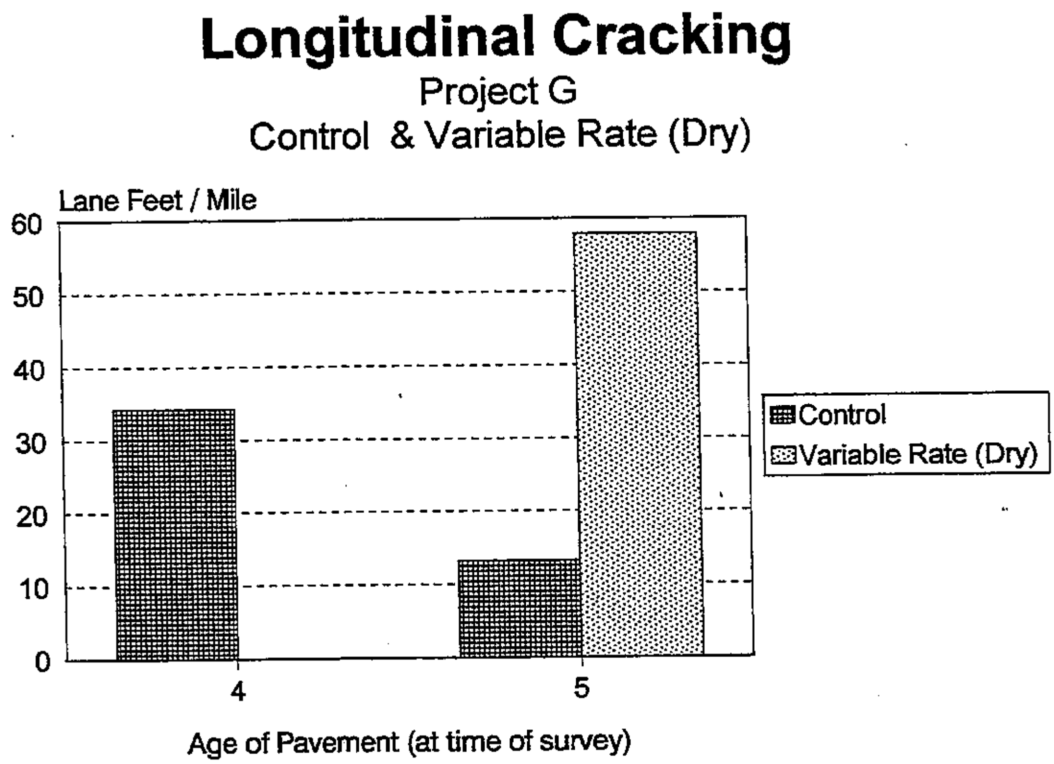


Figure F-41

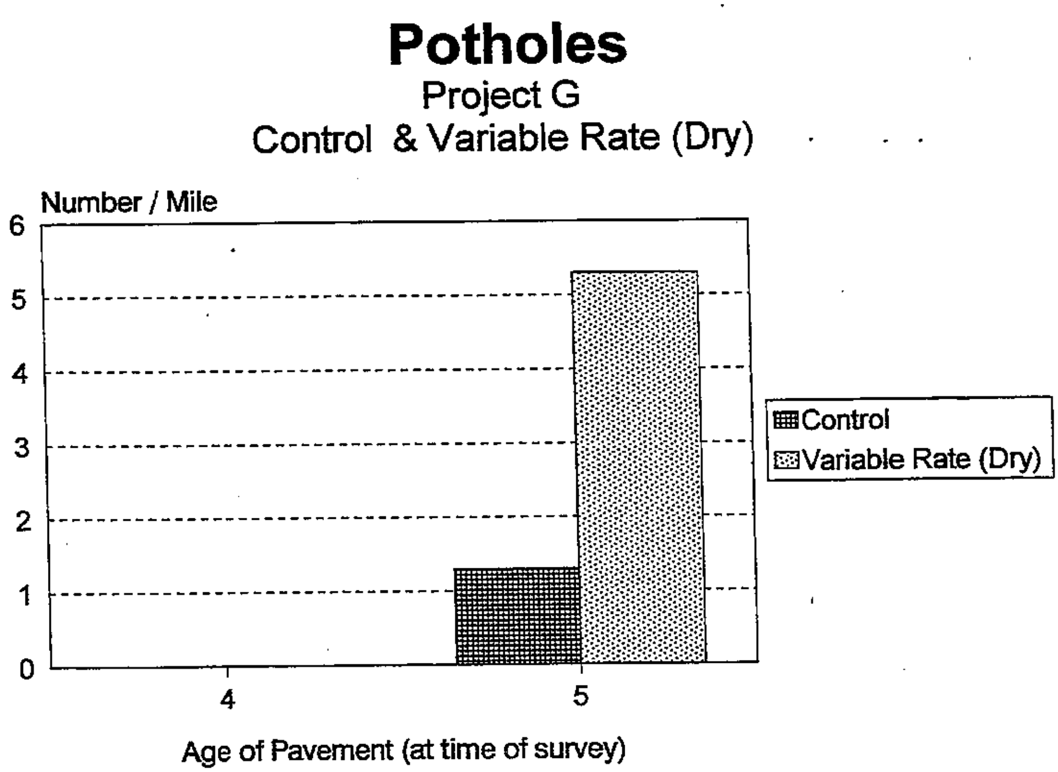


Figure F-42

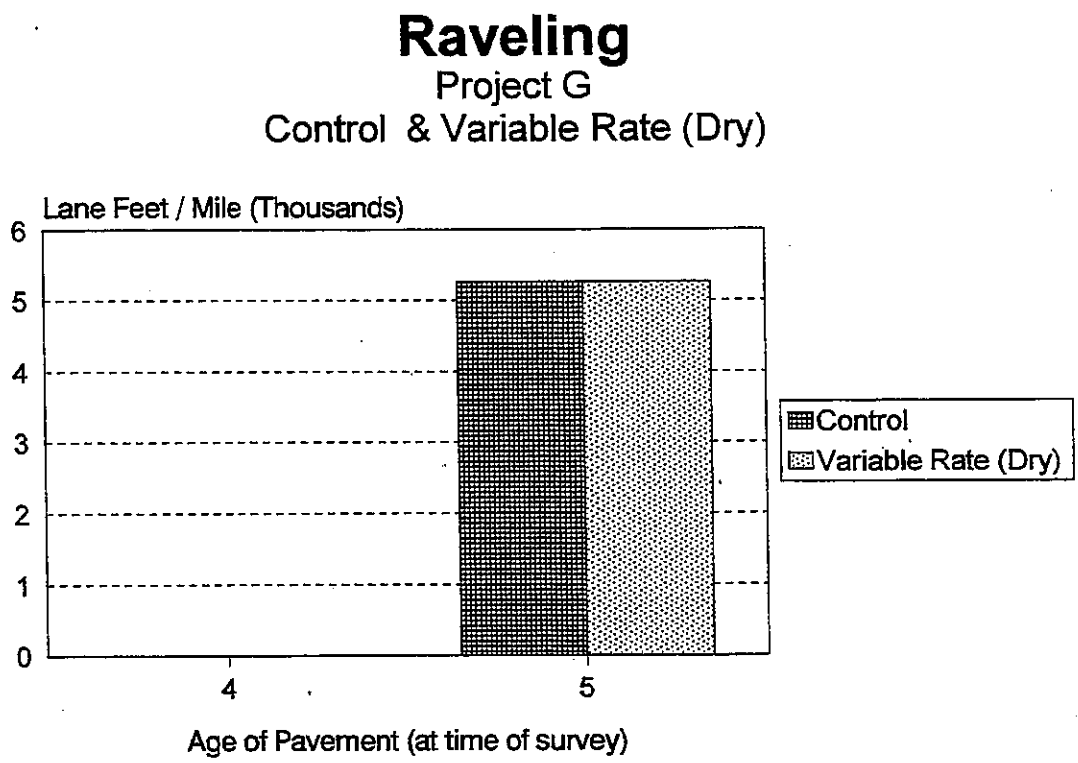


Figure F-43

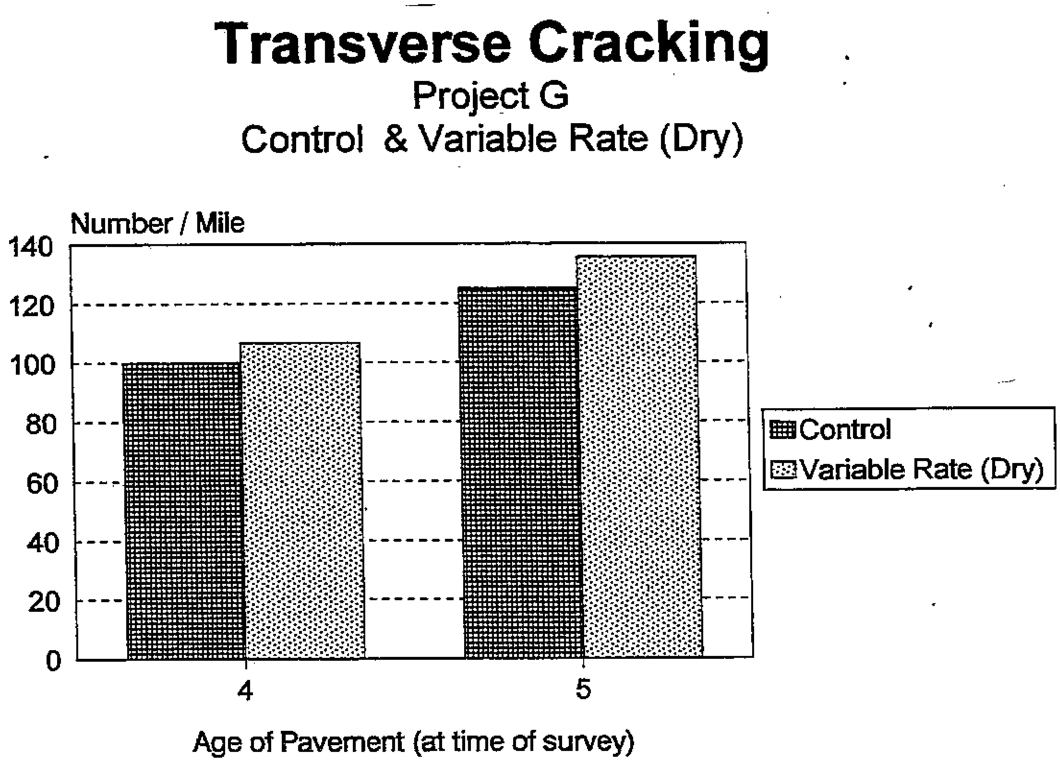


Figure F-44

Alligator Cracking

Project H
Fixed Rate (Dry)

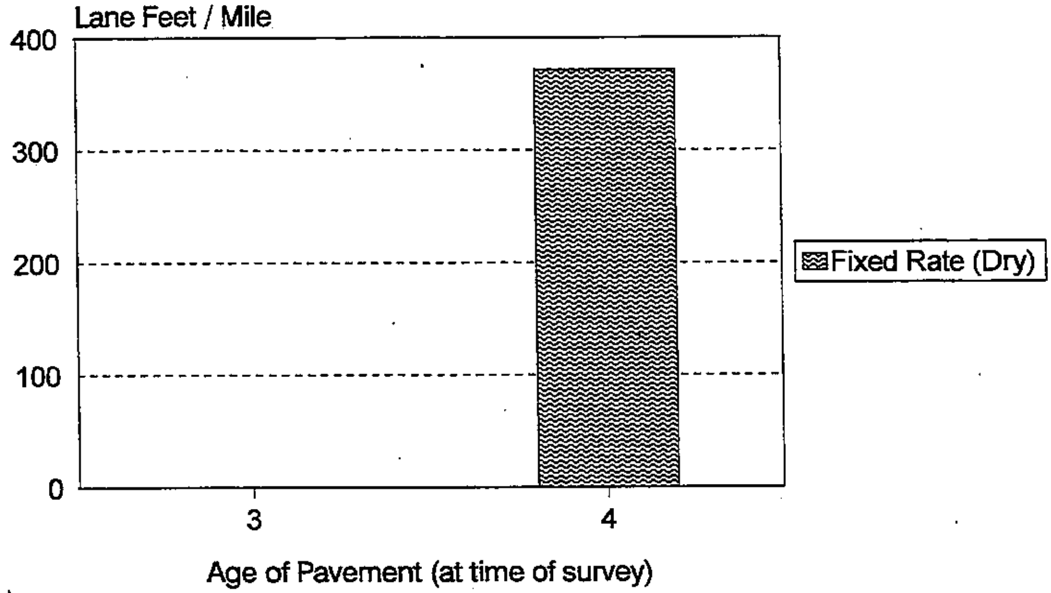


Figure F-45

Bleeding

Project H
Fixed Rate (Dry)

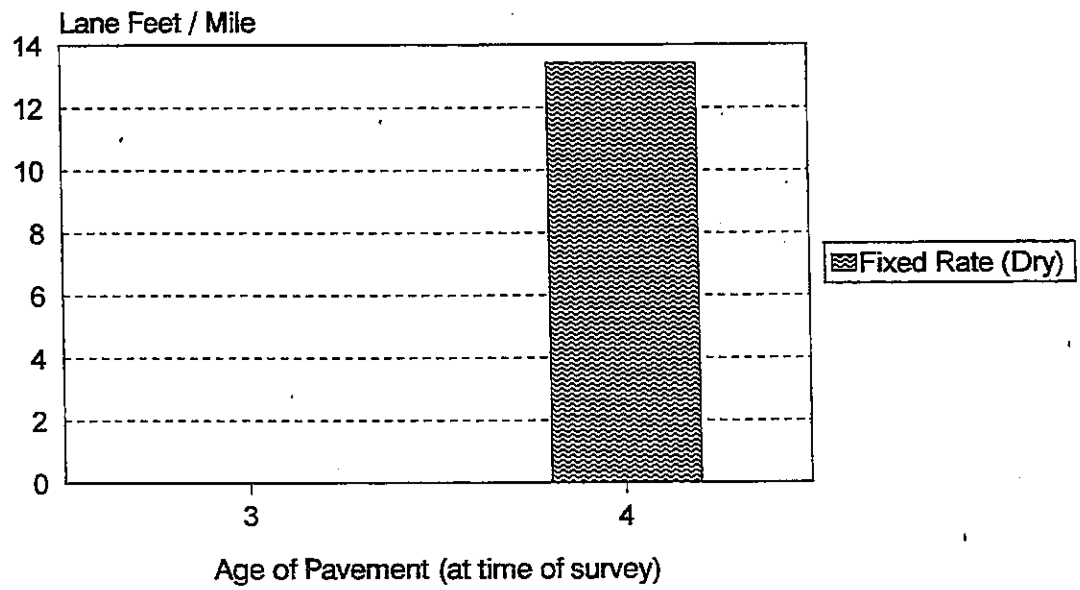


Figure F-46

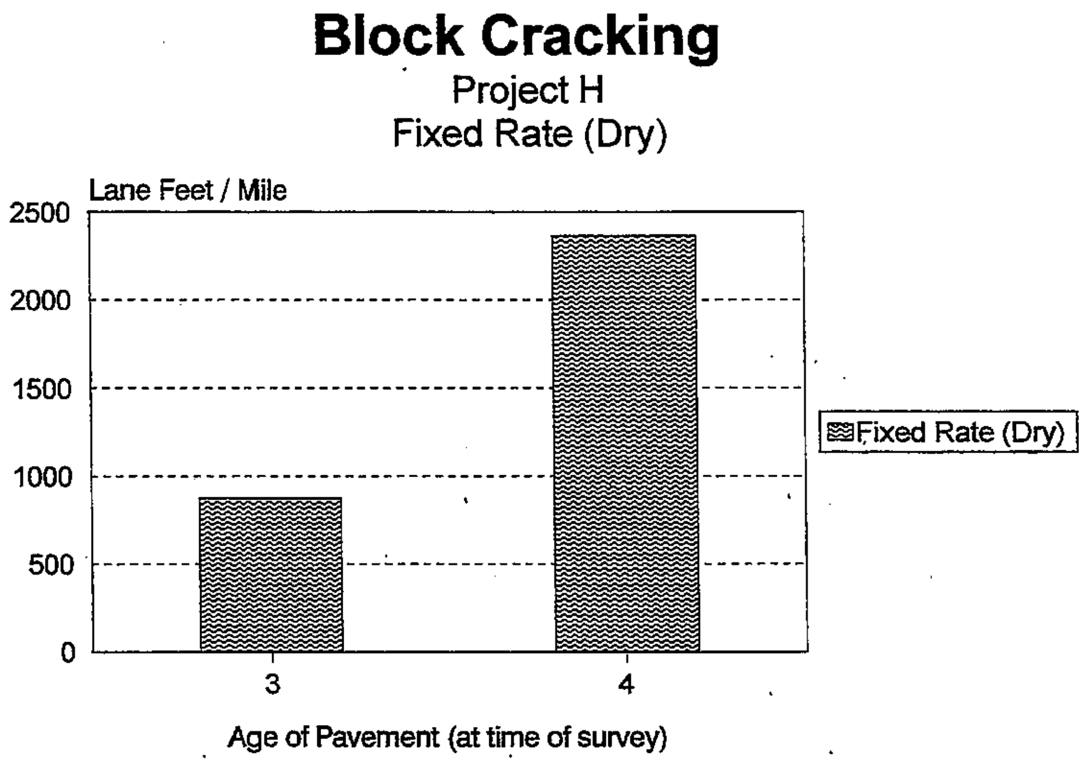


Figure F-47

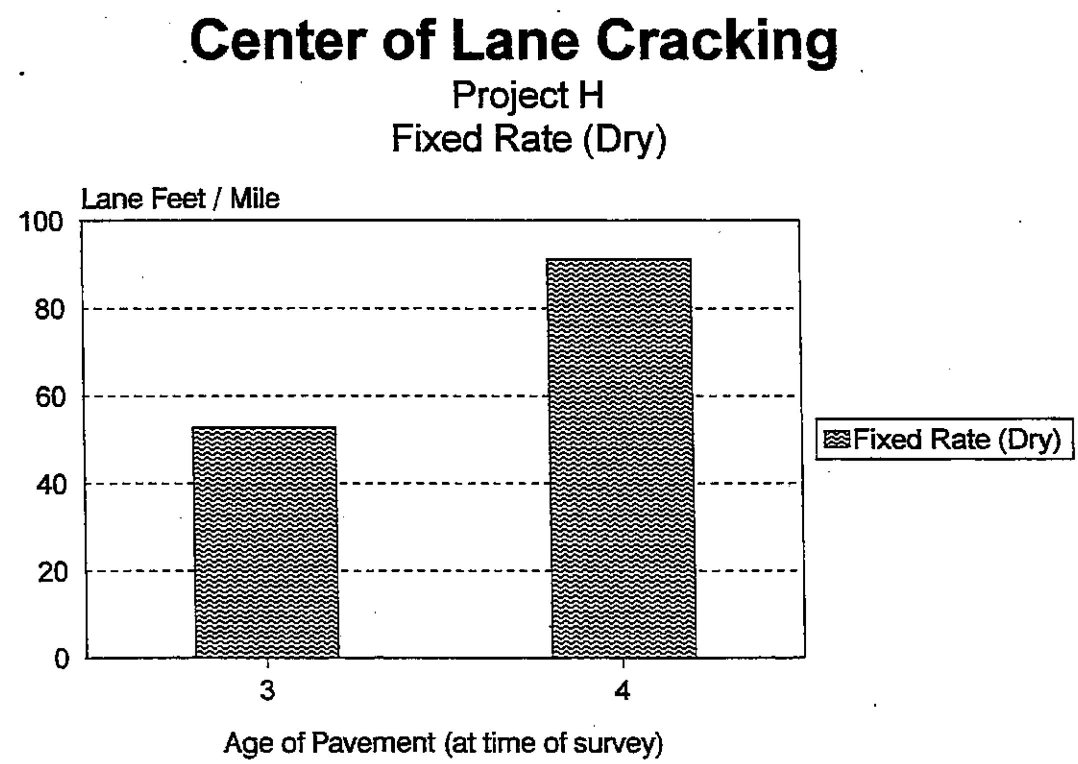


Figure F-48

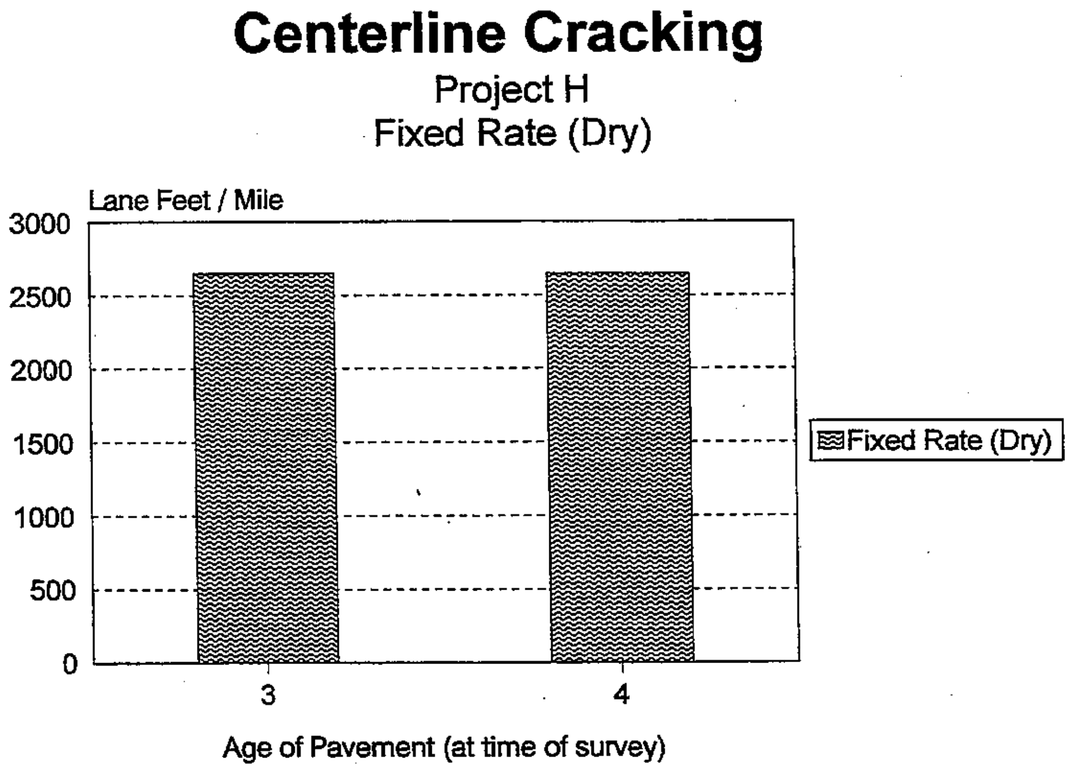


Figure F-49

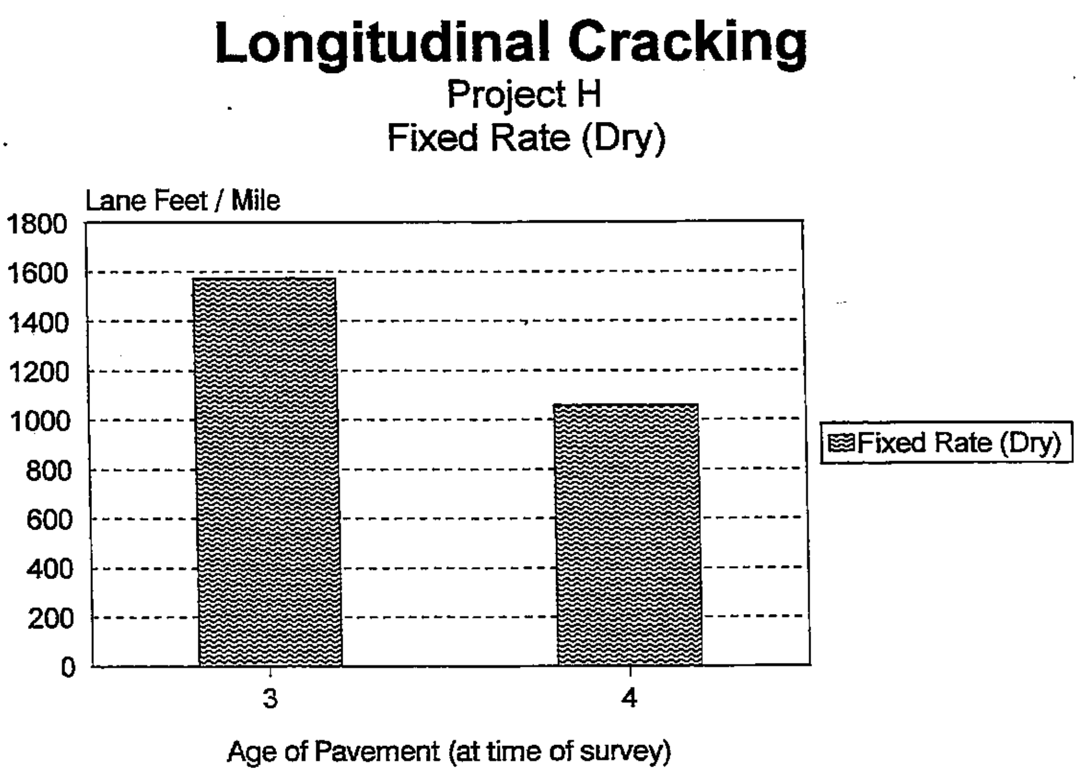


Figure F-50

Potholes

Project H
Fixed Rate (Dry)

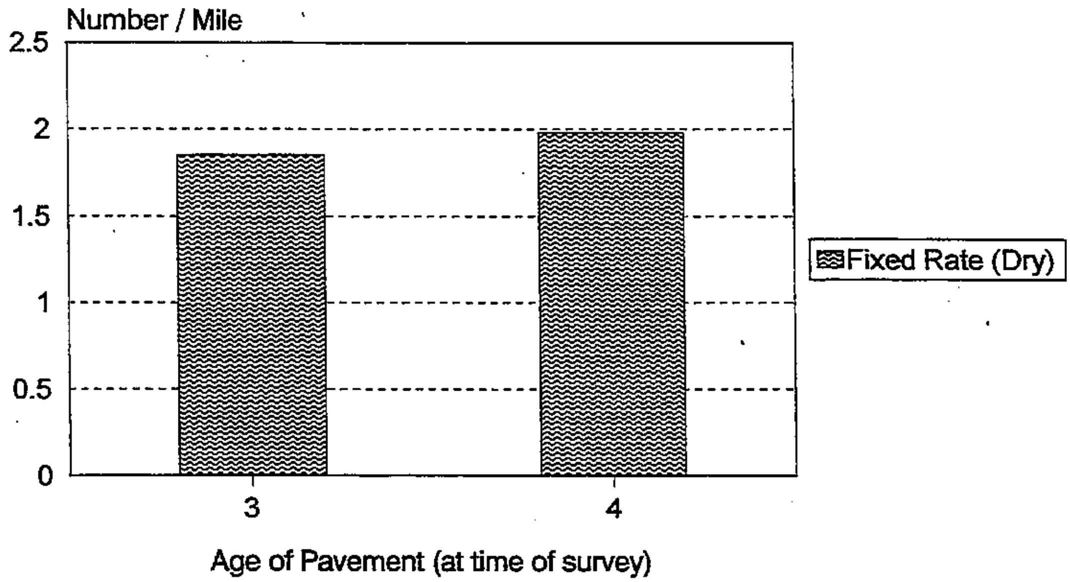


Figure F-51

Raveling

Project H
Fixed Rate (Dry)

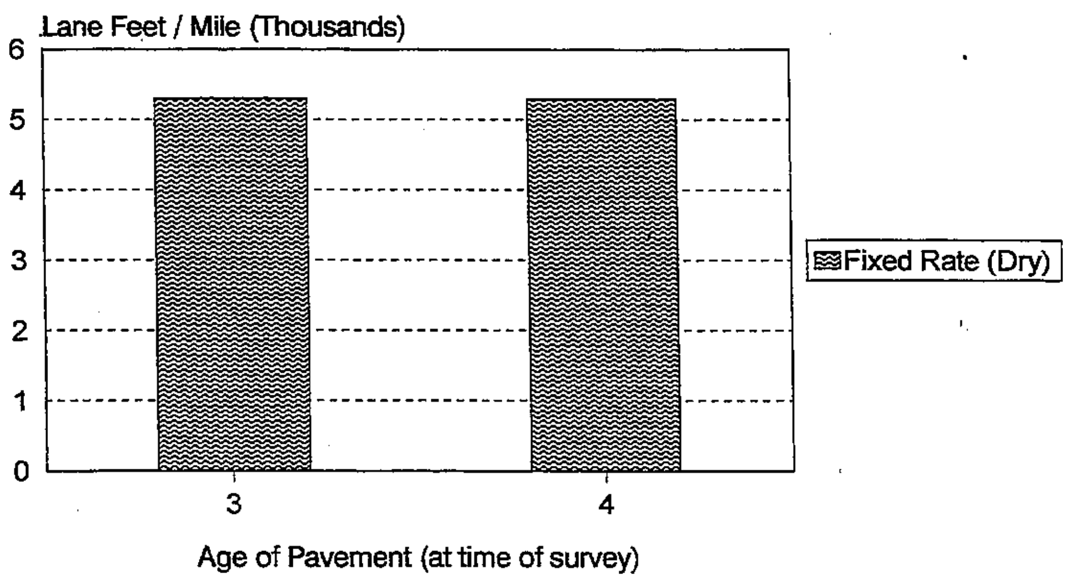


Figure F-52

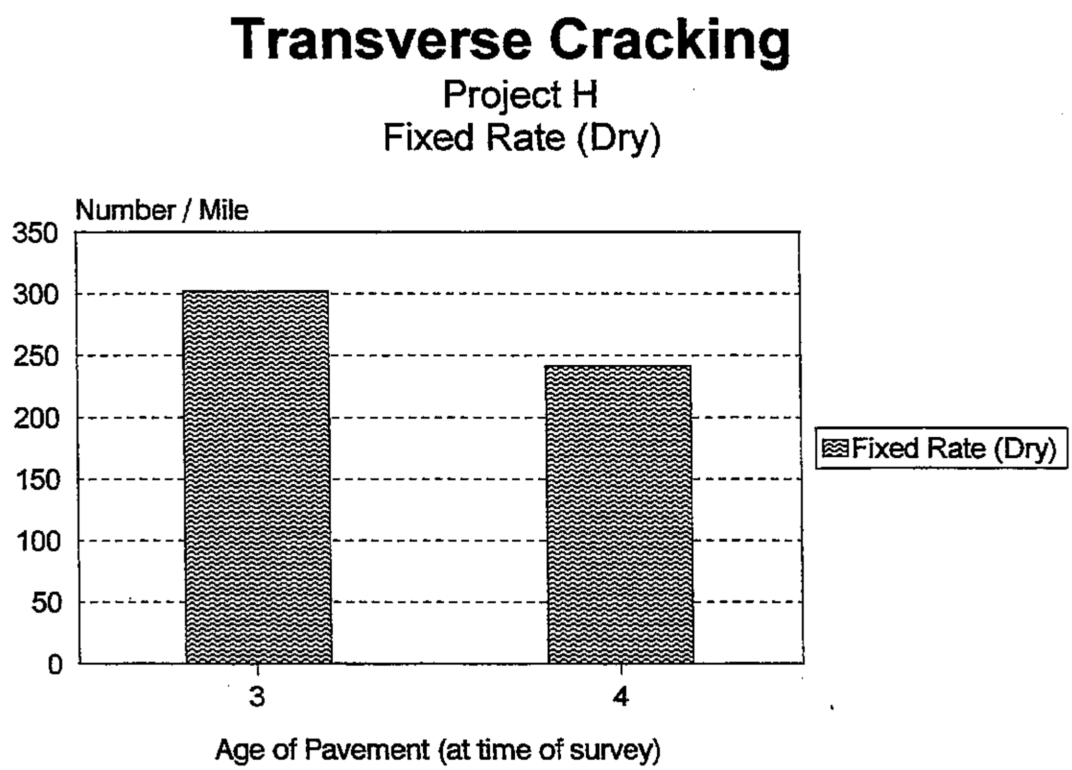


Figure F-53

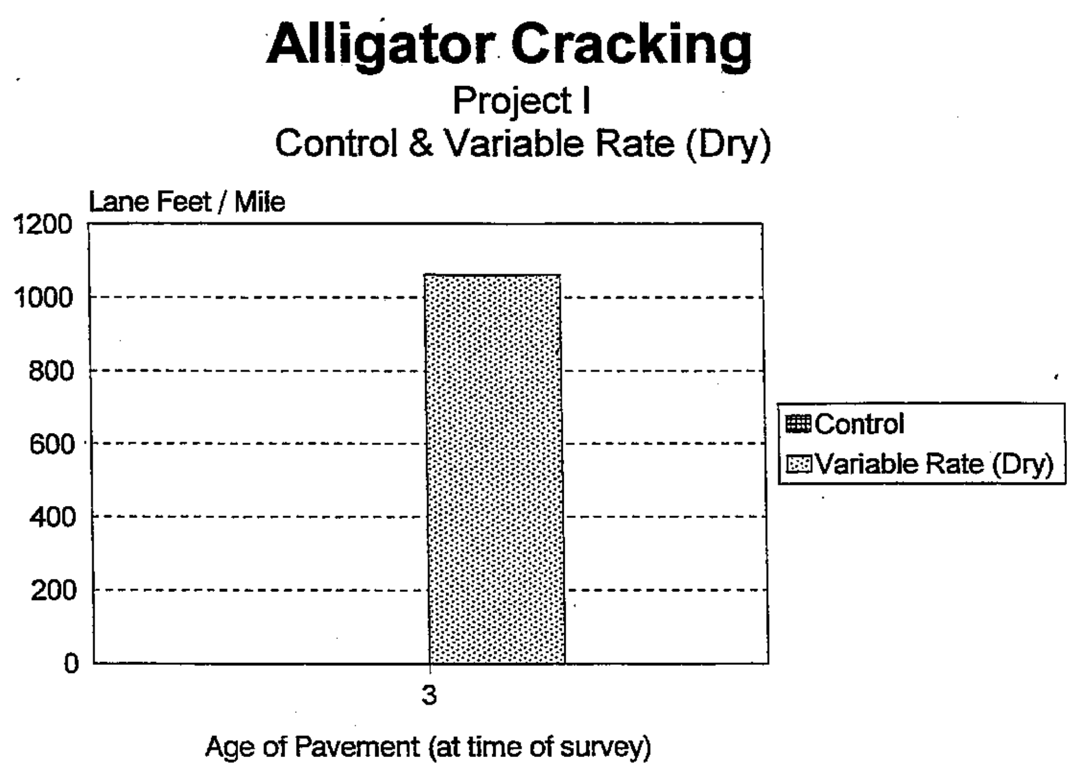


Figure F-54

Centerline Cracking

Project I

Control & Variable Rate (Dry)

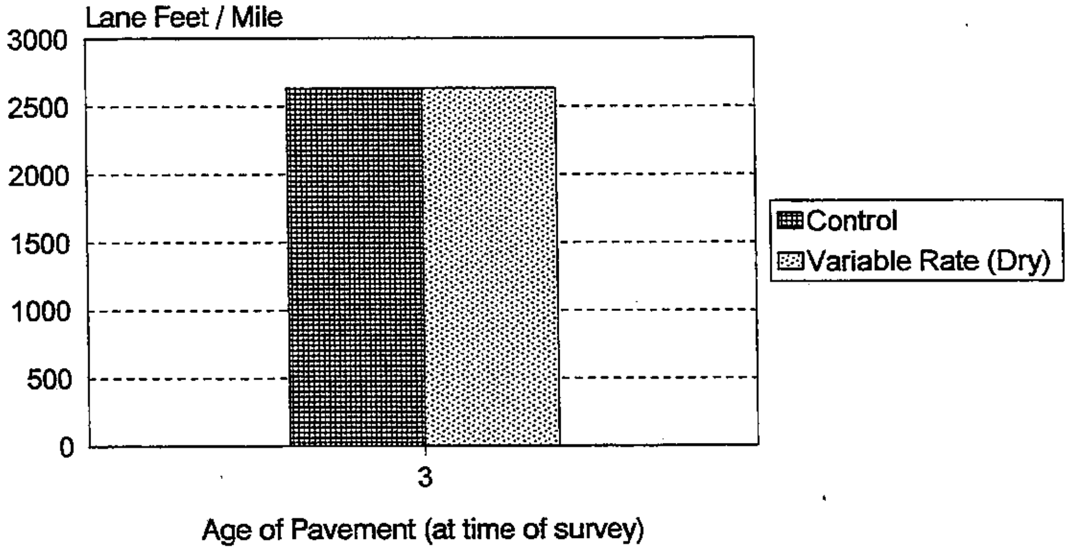


Figure F-55

Longitudinal Cracking

Project I

Control & Variable Rate (Dry)

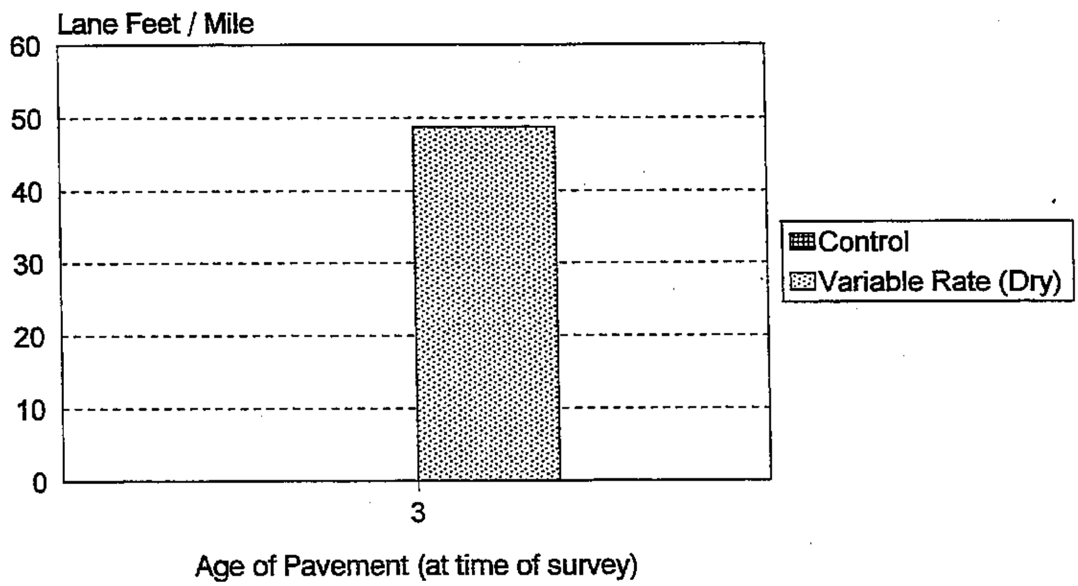


Figure F-56

Raveling

Project I
Control & Variable Rate (Dry)

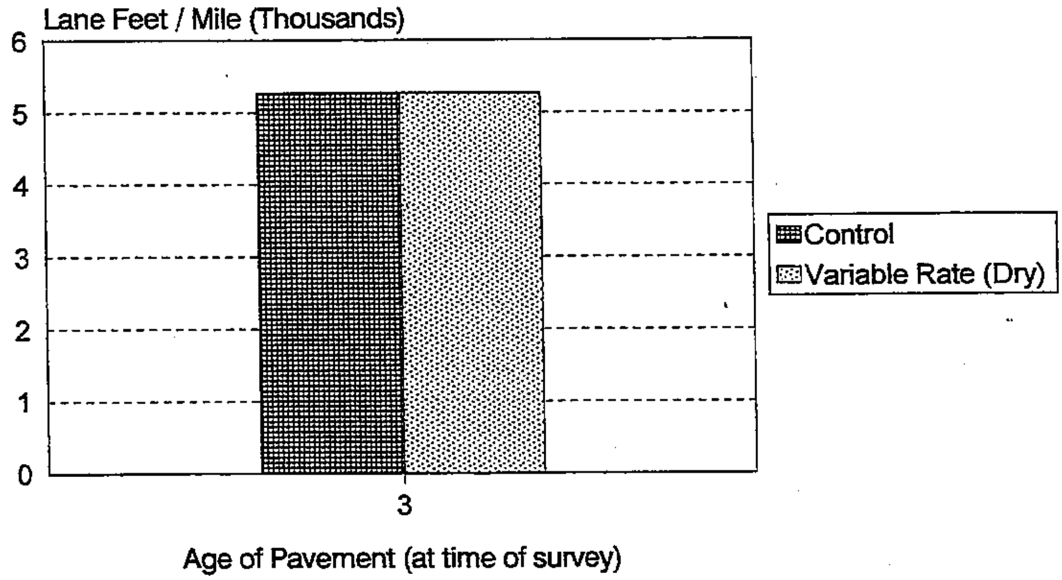


Figure F-57

Transverse Cracking

Project I
Control & Variable Rate (Dry)

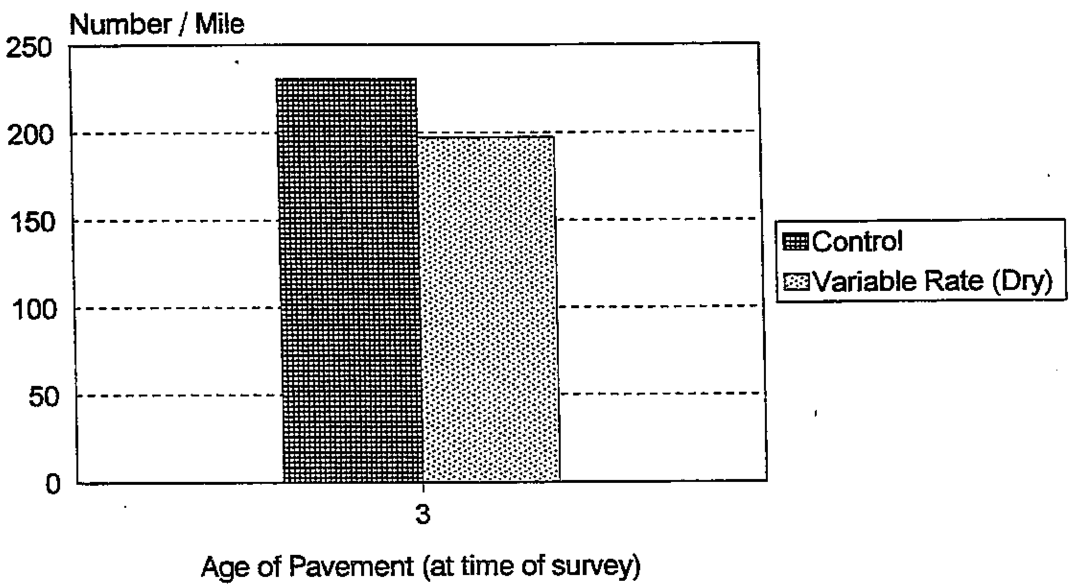


Figure F-58

Alligator Cracking

Project K
Control, Variable Rate (Dry), & Fixed Rate (Dry)

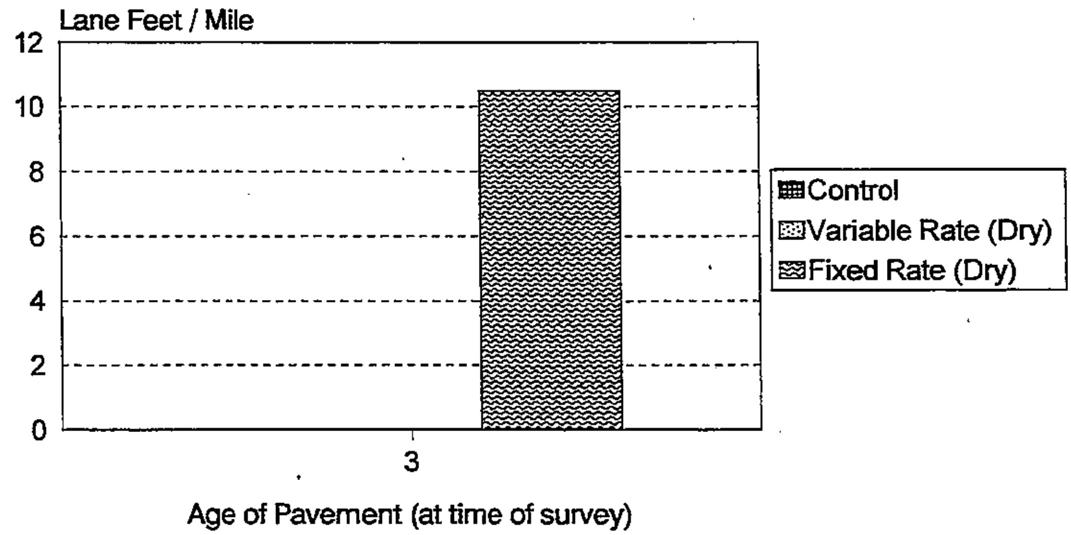


Figure F-59

Bleeding

Project K
Control, Variable Rate (Dry), & Fixed Rate (Dry)

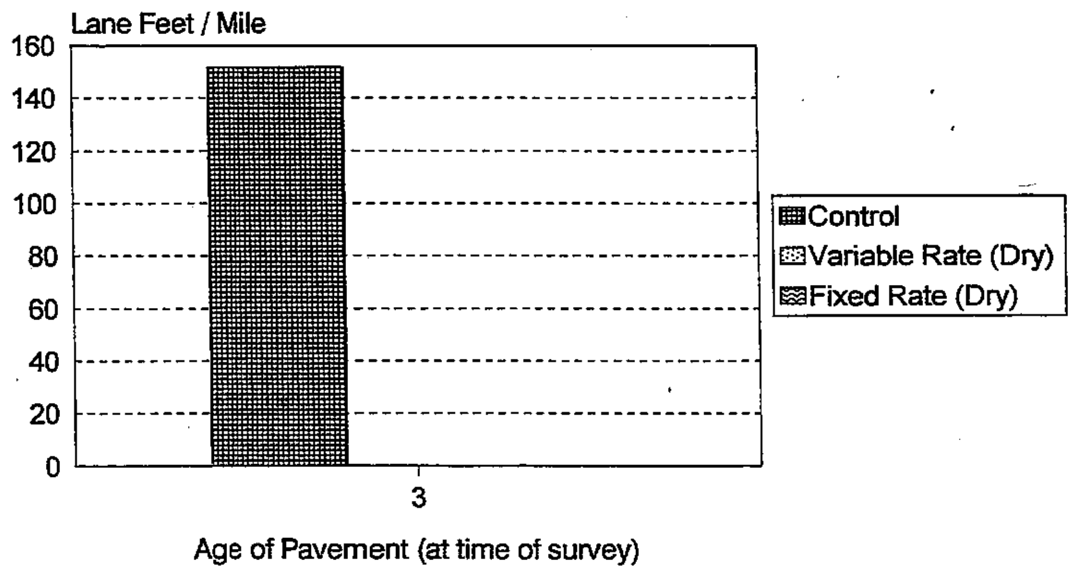


Figure F-60

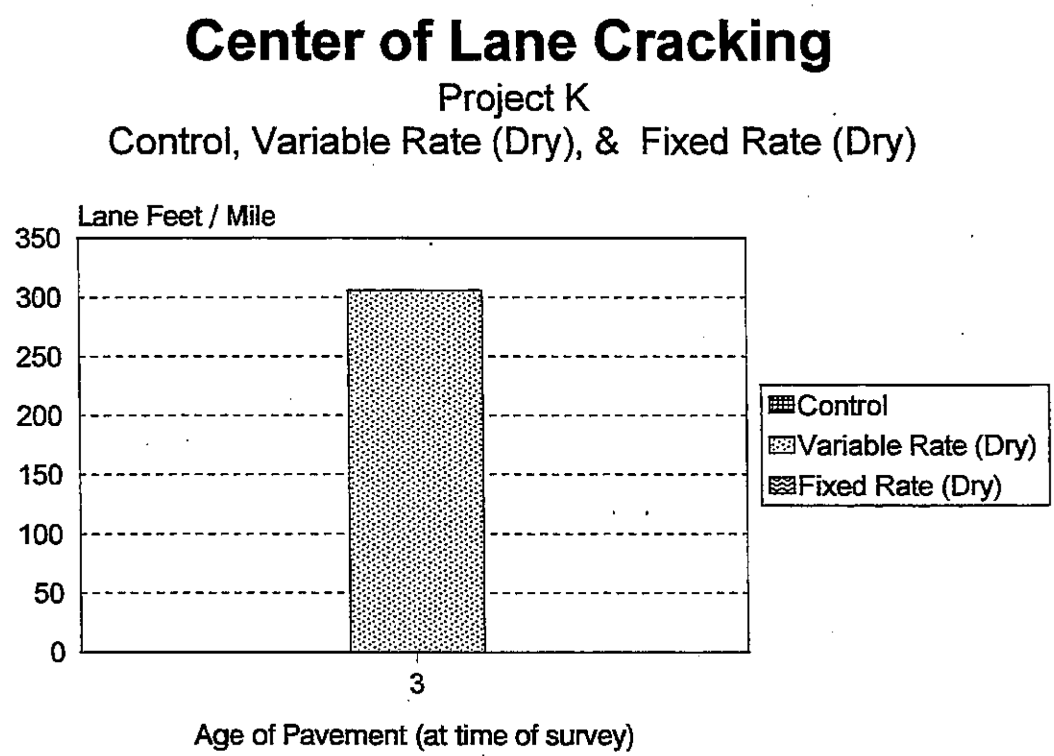


Figure F-61

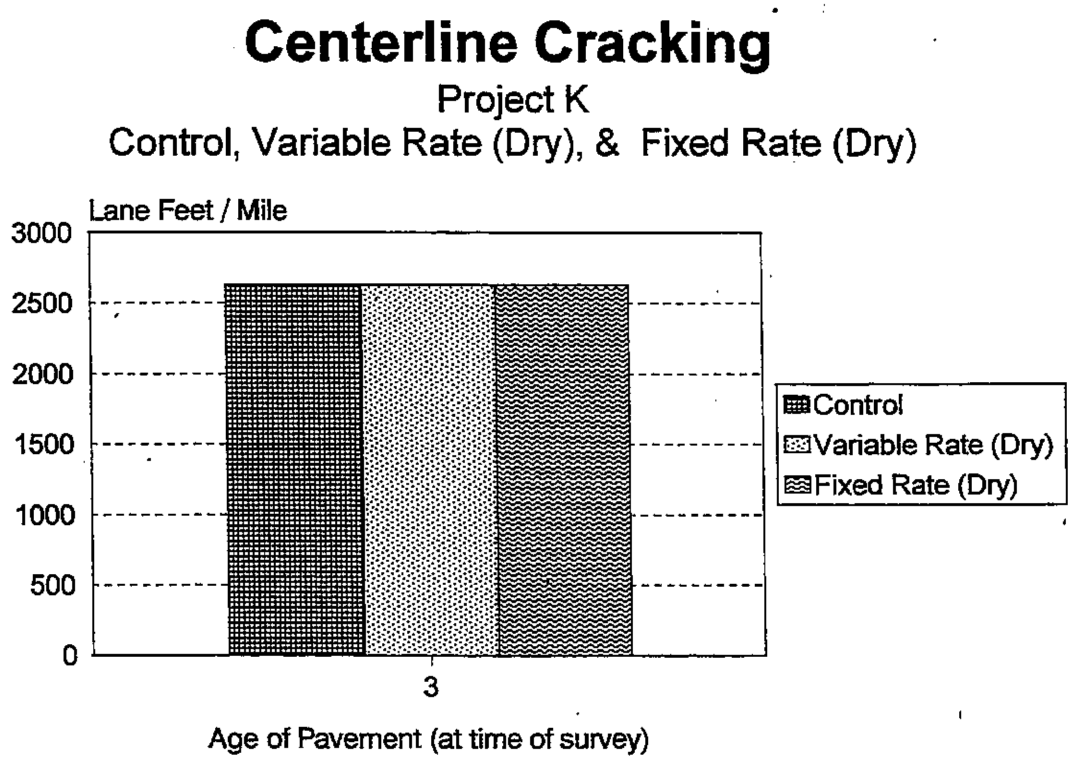


Figure F-62

Longitudinal Cracking

Project K

Control, Variable Rate (Dry), & Fixed Rate (Dry)

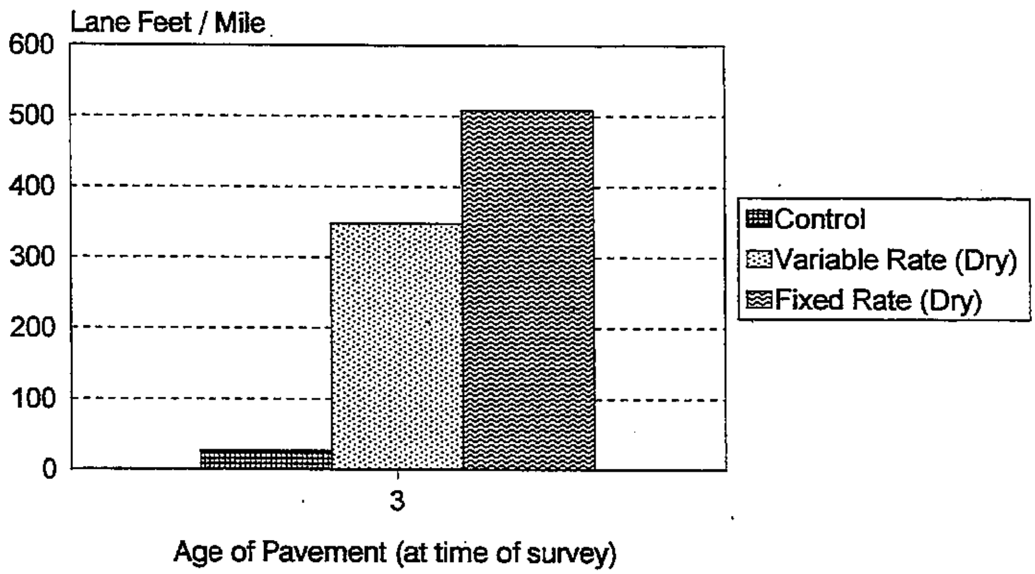


Figure F-63

Potholes

Project K

Control, Variable Rate (Dry), & Fixed Rate (Dry)

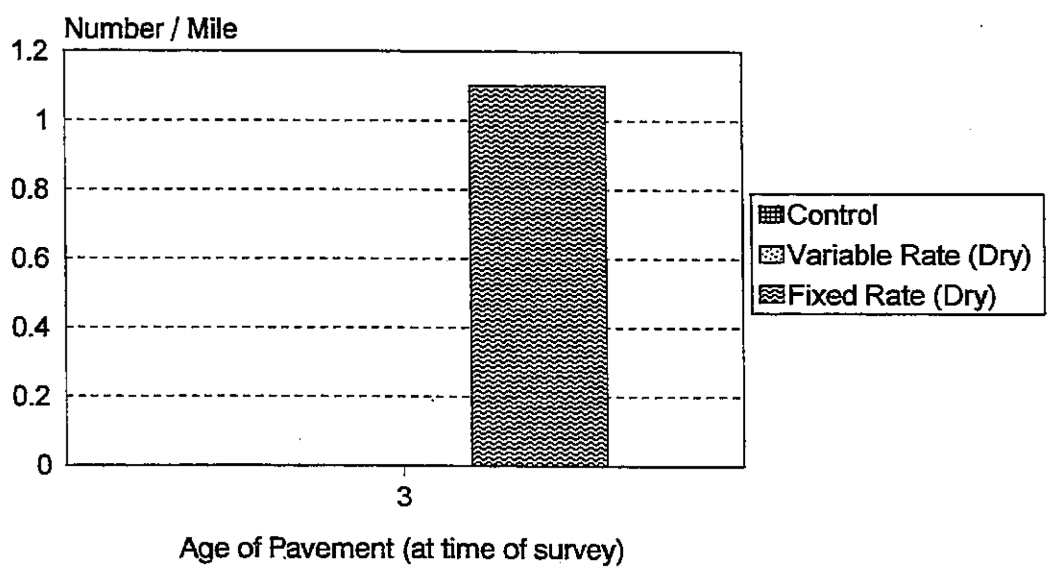


Figure F-64

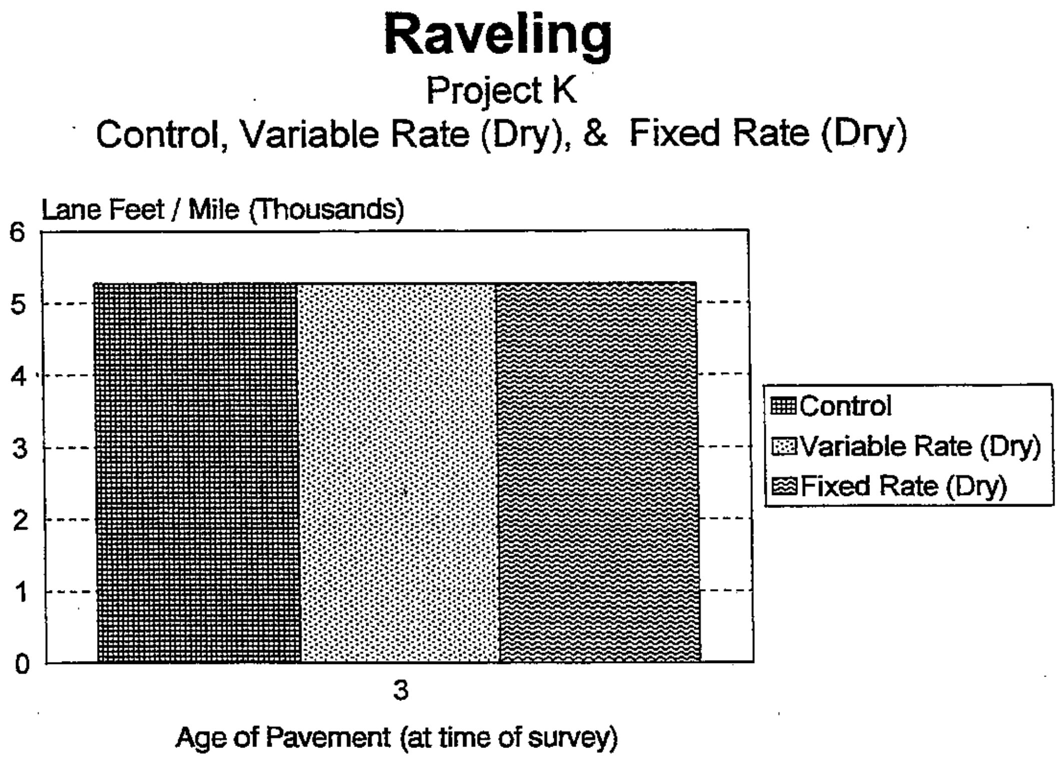


Figure F-65

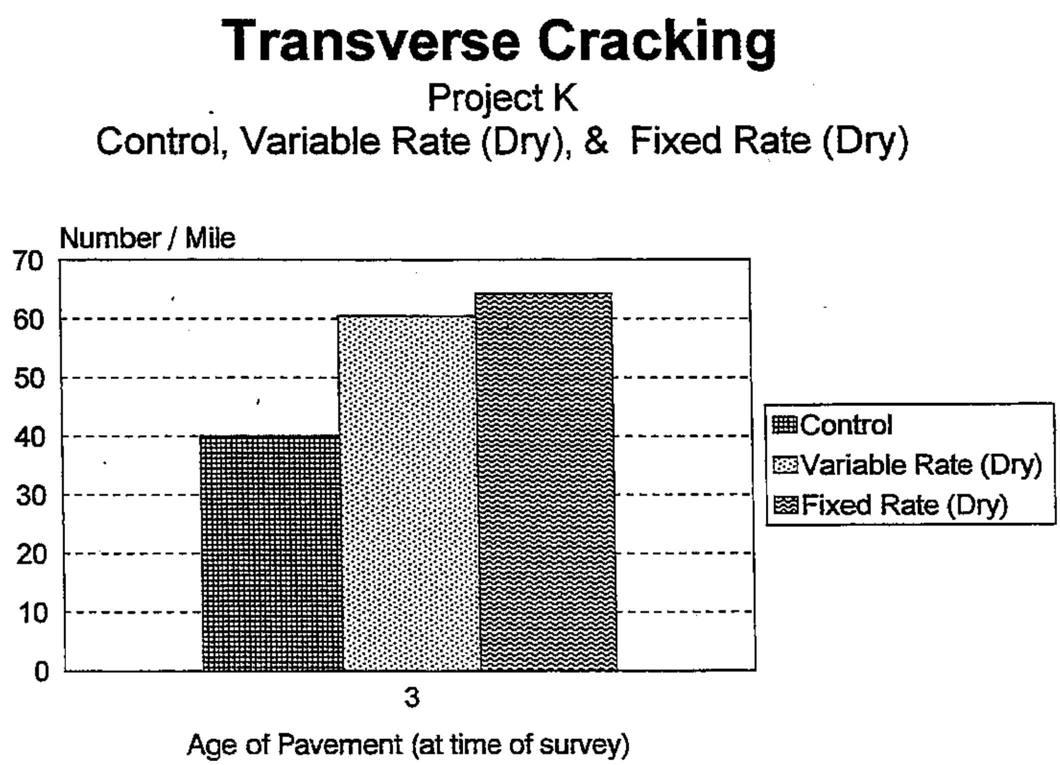


Figure F-66

APPENDIX G

Average Friction Numbers

Average Treaded Tire Friction Numbers

Rubberized Asphalt Pavements

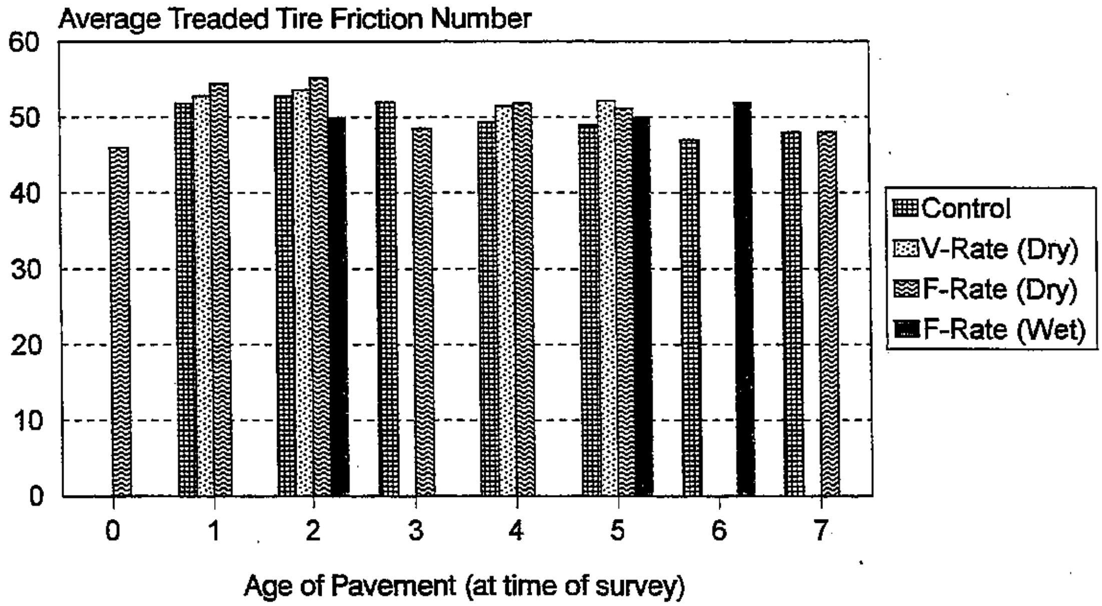


Figure G-1

Average Smooth Tire Friction Numbers

Rubberized Asphalt Pavements

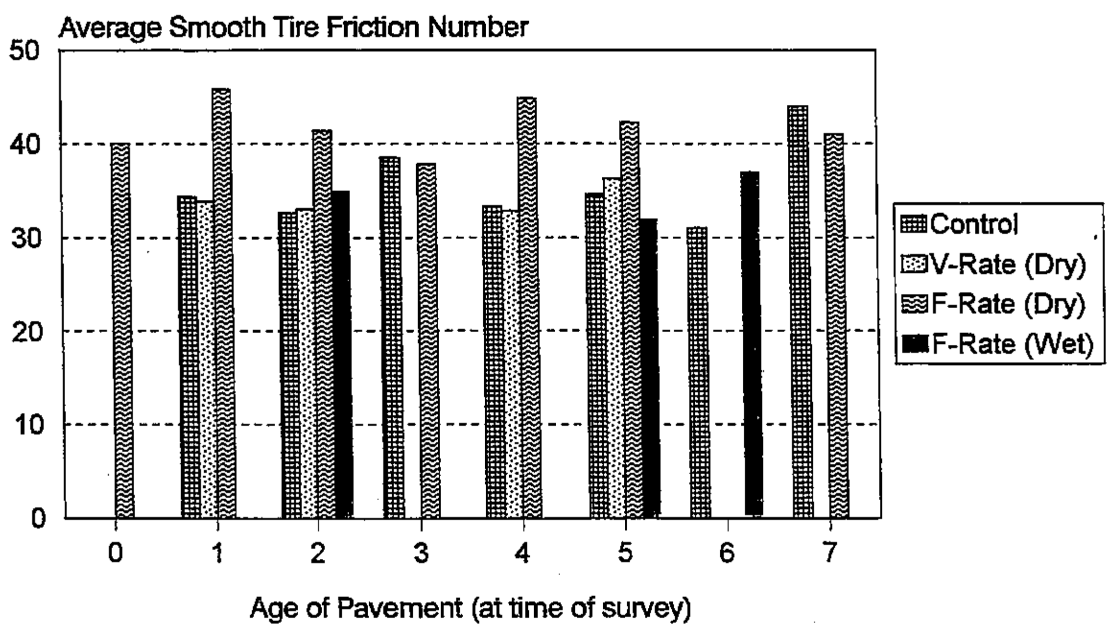


Figure G-2